DOCUMENT RESUME

ED 461 493 SE 061 077

AUTHOR Blank, Rolf K.; Langesen, Doreen
TITLE State Indicators of Science and Mathematics Education, 1997: State-by-State Trends and New Indicators from the 1995-96 School Year.
INSTITUTION Council of Chief State School Officers, Washington, DC. State Education Assessment Center.
SPONS AGENCY National Science Foundation, Arlington, VA. Directorate for Education and Human Resources.
ISBN ISBN-1-884037-40-2
PUB DATE 1997-00-00
NOTE 129p.; For the 1999 edition, see ED 438 173. Published biennially.
AVAILABLE FROM Council of Chief State School Officers, One Massachusetts Avenue, N.W., Suite 700, Washington, DC 20001-1431 ($18). Tel: 202-336-7016. For full text: http://www.ccsso.org/pdfs.Indicators97.pdf.
PUB TYPE Numerical/Quantitative Data (110) -- Reports - Research (143)
EDRS PRICE EDRS Price MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Academic Achievement; Demography; *Educational Improvement; *Educational Trends; Elementary Secondary Education; Mathematics Curriculum; *Mathematics Education; National Organizations; Science Curriculum; *Science Education; *State Standards; Teaching Methods

ABSTRACT

This report on science and mathematics indicators is intended to assist state, national, and local policymakers and educators in making informed decisions. This report focuses on science and mathematics indicators at state and national levels. The indicators are intended for use by policymakers and educators to assess progress in improving mathematics and science education in the schools. The 1997 report presents new state indicators from the 1995-96 school year and examines trends by state from 1990 to 1996 on indicators of student achievement, content and instruction, and context and conditions for teaching. Indicators were selected through consultation with state education leaders, science and mathematics educators, representatives of national professional organizations, and education researchers. (Contains 61 references, 32 tables, and 14 figures.) (ASK)

Reproductions supplied by EDRS are the best that can be made from the original document.

ED 461 493

State Indicators of Science and Mathematics Education 1997

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY

B. Rothenberg

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

2A

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

State-by-State Trends and New Indicators from the 1995–96 School Year

SE041077

BEST COPY AVAILABLE

COUNCIL OF CHIEF STATE SCHOOL OFFICERS
State Education Assessment Center

State Indicators of Science and Mathematics Education 1997

State-by-State Trends and New Indicators from the 1995–96 School Year

Rolf K. Blank
Doreen Langesen

The development of State Science and Mathematics Indicators has been supported by a grant from the National Science Foundation. The indicators were developed and reported through the cooperation of 52 state education agencies and the National Center for Education Statistics of the U.S. Department of Education.

The Council of Chief State School Officers (CCSSO) is a nationwide, nonprofit organization of public officials who head departments of elementary and secondary education in the states, the District of Columbia, the Department of Defense Dependent Schools, and five extra-state jurisdictions. CCSSO seeks its members' consensus on major education issues and expresses their view to civic and professional organizations, federal agencies, Congress, and the public. Through its structure of standing and special committees, the Council responds to a broad range of concerns about education and provides leadership on major education issues.

The State Education Assessment Center is a permanent, central part of the Council of Chief State School Officers. This Center was established through a resolution by the membership of CCSSO in 1984.

The State Science and Mathematics Indicators were developed through cooperation of the Council with all of the state departments of education, the National Science Foundation, and the U.S. Department of Education. The Indicators were selected and designed to provide valid, comparable state-by-state and national data on the condition of science and mathematics education in elementary and secondary schools. Data are reported every two years using a consistent set of indicators.

The Report is supported by a grant from the National Science Foundation, Division of Research, Evaluation, and Communication of the Education and Human Resources Directorate.

COUNCIL OF CHIEF STATE SCHOOL OFFICERS

Wilmer S. Cody (Kentucky), President

Robert E. Bartman (Missouri), President-elect

Delaine A. Eastin (California), Richard P. Mills (New York), John M. Goff (Ohio)

Co-Chairs, Task Force on Standards and Assessments for Students and Teachers

Gordon M. Ambach, Executive Director

Wayne N. Martin, Director, State Education Assessment Center

Rolf K. Blank, Director, Education Indicators Programs

Copies of this report may be ordered for $18.00 per copy from:

Council of Chief State School Officers

Attn: Publications

One Massachusetts Avenue NW

Suite 700

Washington, DC 20001-1431

ISBN # 1-884037-40-2

Copyright ©1997 by the Council of Chief State School Officers, Washington, DC

All rights reserved with the exception of reproduction for educational purposes.

4

Acknowledgments

This report is the result of successful cooperation of the Council of Chief State School Officers with the state departments of education, the National Science Foundation (NSF), and the U.S. Department of Education. The State Science and Mathematics Indicators were initiated in 1986 as a result of the commitment of the National Science Foundation to improving the quality of information on science and mathematics education in the nation's schools. The Council's work in developing a system of state-level indicators of science and mathematics education is made possible by the collective decision of the state superintendents and commissioners to have valid, comparable state-by-state data to assess educational progress.

The Science and Mathematics Indicators receive strong support from each of the state superintendents and commissioners. State data managers, science and mathematics specialists, and assessment directors have willingly given their time, expertise, and assistance to the project. State education staff have played active roles in the selection of indicators and design of a data reporting system, and some indicators are based on data from state education information systems.

The Council very much appreciates the strong support by the National Science Foundation for development and continuation of the State Science and Mathematics Indicators. We particularly acknowledge Bernice Anderson, NSF program officer, and Larry Suter, deputy director of the Division of Research, Evaluation, and Communication at NSF, who have provided important guidance and suggestions throughout development of the state indicators. The National Center for Education Statistics of the U.S. Department of Education provided state-by-state data analyses from the Schools and Staffing Survey for this report. Results from the NAEP Trial State Assessment in mathematics and science are also reported as state indicators. We very much appreciate the support and assistance of NCES.

The Council staff and the states have benefitted greatly from the insightful recommendations and suggestions of expert advisors since the beginning of our work. State leaders, science and mathematics educators, researchers, and federal agency staff who advise us have ensured that the indicators are soundly based on research and that they provide important information for policy and program decisions. We very much appreciate the suggestions, useful advice, and excellent work of our designers for the 1997 report, Colorado Design Associates, Washington, DC.

Contents

Acknowledgments iii

Summary of State Science and Mathematics Indicators: 1997 ix

Introduction: Development of State Education Indicators for Policymakers 1

- How Are State Indicators Selected? Are They Comparable and Reliable? 2
- What Are the Sources of Data? 3
- Organization of the Report 4

Chapter One: Indicators of Student Achievement in Mathematics and Science 5

- Student Proficiency on NAEP 5
- Mathematics and Science Proficiency by Student Race/Ethnicity and Gender 13
- Students Taking Advanced Placement Examinations 18

Chapter Two: Indicators of Mathematics and Science Content and Instruction 23

- Course Enrollments in High School Mathematics and Science 25
- State Policies and Course Enrollment Trends 36
- Middle Grades Mathematics and Science Course Enrollments 40
- Course Enrollments by Race/Ethnicity and Gender 42
- Instructional Practices in Mathematics and Science 46
- Elementary Class Time on Math and Science 50

Chapter Three: Indicators of Teacher Preparation and Supply 53

- Teachers Certified in Assigned Field 53
- Teachers with a Major in Assigned Field 58
- Indicators of Race/Ethnicity and Gender in the Teaching Force 65
- New Teachers in Math and Science 74

Chapter Four: Indicators of Context and Conditions for Teaching 77

Conclusions: Use of Science and Mathematics Indicators to Analyze Policies 84

List of Abbreviations 86

References 87

Appendix A. Student Background Data, State Policies, Urban School Indicators 91

Appendix B. NAEP Sample Questions 105

Appendix C. Data Sources and Computations 115

Appendix D. Directory of State Course Titles by Reporting Categories 119

List of Tables and Figures

Table 1:	Mathematics Proficiency of Grade 8 Students, 1996 NAEP; Improvement 1990 to 1996	8
Table 2:	Mathematics Proficiency of Grade 4 Students, 1996 NAEP; Improvement 1992 to 1996	11
Table 3:	Science Proficiency of Grade 8 Students, 1996 NAEP	12
Table 4:	Race/Ethnic Differences in Basic Mathematics Level for Grade 8 Students, 1996 NAEP	15
Table 5:	Students Taking Advanced Placement Examinations in Mathematics and Science, 1996, and Trends 1992 to 1996	19
Table 6:	Minority and Female Students Taking Advanced Placement Examinations in Mathematics and Science, 1996; Change 1992 to 1996 in Minority Participation	21
Table 7:	Students Taking Higher-Level Mathematics Courses by Graduation, 1996	27
Table 8:	Integrated Mathematics Course Enrollments, 1996	28
Table 9:	Students Taking Algebra 1/Integrated Math 1 and Algebra 2/Integrated Math 3 as a Percent of Students in Each High School Grade, 1996	29
Table 10:	Students Taking Higher-Level Science Courses by Graduation, 1996	32
Table 11:	Students Taking Earth Science, Physical Science, General Science, and Integrated Science as a Percent of Grade 9 Students, 1996	34
Table 12:	Students Taking First-Year Biology as a Percent of Students in Each High School Grade, 1996	35
Table 13:	Change in Higher-Level Mathematics Enrollments and State Graduation Requirements, 1990 to 1996	38
Table 14:	Change in Higher-Level Science Enrollments by State Graduation Requirements, 1990 to 1996	39
Table 15:	Middle Grades Mathematics and Science Course Enrollments, 1996	41
Table 16:	Race/Ethnic Differences in Students Taking Chemistry and Algebra 2/Integrated Math 3, 1996	43
Table 17:	Gender Differences in Students Taking Higher-Level Mathematics and Science Courses, 1990 to 1996	45
Table 18:	Instructional Practices in Mathematics, Grade 4, 1996 NAEP	47
Table 19:	Instructional Practices in Mathematics, Grade 8, 1996 NAEP	49
Table 20:	Elementary Class Time per Week on Math and Science, Grades 4–6, 1991 to 1994	51
Table 21:	Certification of Mathematics and Science Teachers, Grades 9–12, 1996	55
Table 22:	Certification of Mathematics and Science Teachers, Grades 7–8, 1996	57
Table 23:	Mathematics and Science Teachers with Major in Assigned Field, Grades 7–12, 1994	60
Table 24:	Professional Development of Teachers on Mathematics Education (in last year), 1996 NAEP	64
Table 25:	Minority Teachers in Mathematics and Science by Minority Students in State, 1996	66
Table 26:	Female Teachers in High School Math and Science: 1990 to 1996	67
Table 27:	Age of Mathematics Teachers, 1990 to 1996	71
Table 28:	Age of Physics Teachers, 1990 to 1996	73

Table 29: New Teachers in High School Science and Mathematics, 1996 75

Table 30: Students Taking Mathematics and Science per Teacher, Grades 9–12 78

Table 31: Availability and Use of Computers in Mathematics Instruction, Grade 4, 1996 NAEP 82

Table 32: Availability and Use of Computers in Mathematics Instruction, Grade 8, 1996 NAEP 83

FIGURES

Figure 1: Percent of Grade 8 Students At or Above Proficient Mathematics Level, 1990 to 1996 NAEP 7

Figure 2: Percent of Students in Grade 4 At or Above Proficient Mathematics Level, 1992 to 1996 NAEP 10

Figure 3: Disparity in Basic Mathematics Level Between Largest Minority Group and White Students, Grade 8, 1992 to 1996 NAEP 14

Figure 4: Percent of High School Students Taking Algebra 2/Math Level 3 by Graduation, 1990 to 1996 26

Figure 5: Percent of High School Students Taking Chemistry by Graduation, 1990 to 1996 31

Figure 6: Science Instructional Practices 48

Figure 7: Average Hours Per Week Spent on Core Academic Subjects as Reported by Elementary Teachers, 1994 50

Figure 8: Percentage of All Mathematics and Science Teachers with Major or Minor in Field, Grades 7–12, 1994 59

Figure 9: Percentage of Grades 7–12 Science and Mathematics Classes Taught by Teachers with Major in Field, by Percentage of Minority Students in Class 62

Figure 10: Gender of Mathematics Teachers (Percent Female), 1990 to 1996 68

Figure 11: Gender of Chemistry Teachers, Percent Female by State, 1996 69

Figure 12: Mathematics Teachers Age 50 and Over, by State, 1996 72

Figure 13: Average Class Size in High School Mathematics and Science, 1994 80

Figure A.1: High School Students Enrolled in General or Consumer Mathematics, Percent of Grades 9–12, 1990 to 1996 92

The Council of Chief State School Officers' goal in producing this report on science and mathematics indicators is to assist state, national, and local policymakers and educators in making informed decisions. Efforts to reform and restructure science and mathematics education need to be based on a sound assessment of current conditions, the rate of improvement, and problems in the system. This report focuses on science and mathematics indicators at state and national levels.

Improving student learning in mathematics and science is a priority for our elementary and secondary schools. The National Education Goals of the President and governors, set in 1989, state that science and mathematics achievement of American high school graduates will be first in the world by the year 2000. Educators at local, state, and national levels are working to implement national professional standards for mathematics education. The new national standards for science education will further advance science education reform.

The Council has led development of a system of state-by-state indicators of the condition of science and mathematics education. The indicators are intended for use by policymakers and educators to assess progress in improving mathematics and science education in our schools. This report is the fourth in a series of biennial Council reports on State Indicators of Science and Mathematics Education. The 1997 report presents new state indicators from the 1995–96 school year and examines trends, by state, from 1990 to 1996 on indicators of: (a) student achievement; (b) content and instruction; and (c) context and conditions for teaching. The indicators were selected through consultation with state education leaders, science and mathematics educators, representatives of national professional organizations, and education researchers. The Council's work in development of science and mathematics education indicators is supported by the National Science Foundation.

Summary of Indicators for 1997

Student Achievement in Mathematics and Science

Policy Issues: Is student achievement in mathematics and science and improving, and how does achievement compare state to state? Are students learning challenging content?

- ***Student proficiency on NAEP mathematics.*** From 1990 to 1996, 27 states made significant improvement in the percent of grade 8 students reaching the "Proficient" level on the National Assessment of Educational Progress (NAEP) in Mathematics. Eight states had over 30% of students score at/above Proficient level in 1996. Nationally, 23% of students scored at/above the Proficient level in 1996.

- From 1992 to 1996, seven states made significant improvement in the percent of grade 4 students reaching the Proficient level on the NAEP Mathematics Assessment. Six states had at least 25% of students score at/above the Proficient level in 1996. Nationally 20% of grade 4 students scored at/above the Proficient level.

- ***Student proficiency on NAEP science.*** The first state-level NAEP in Science was given to grade 8 students in 1996. The average student proficiency score in 17 states was significantly above the national average. The scores in 11 states were at or near the national average (148 on a scale of 0 to 300), and 14 states were significantly below the national average.

Policy Issue: Are schools improving the performance of all students?

- ***Race/ethnicity and NAEP proficiency.*** Only nine states reduced the disparity in the NAEP Mathematics performance of minority and white students from 1992 to 1996. For the nation, the

white-black disparity in the percent of grade 8 students at/above the Basic level declined by two percentage points over four years; in 1996, 73% of white students scored at/above Basic as compared to 26% of blacks.

- ***Long-term trends on NAEP mathematics and science.*** The scores for white and minority students improved significantly from 1982 to 1994. Black students at age 9 improved 17 points on the NAEP math scale (to 212 on 0–500 scale), while whites increased 13 points (to 237). Science scores for black students at age 17 improved 22 points over 12 years (to 257), as compared to 13 points rise for whites (to 306). A 20 point rise on the scale can be interpreted as an improvement of about two years of school.

Mathematics and Science Content and Instruction

Policy Issue: What proportion of students take challenging, higher-level mathematics and science courses in high school? What courses do middle grade students take?

- ***Higher-level mathematics courses.*** Seven states had over 75% of high school students take three years of high school mathematics by graduation in 1996, as indicated by enrollment in algebra 2 or integrated math 3. Nationally, 62% of students took three years of high school mathematics in 1996, as compared to 49% in 1990, or an increase of 13 percentage points in six years.

- ***Higher-level science courses.*** Seven states had over 65% of high school students take three years of high school science by graduation in 1996, as indicated by enrollment in chemistry. Nationally, 55% of students took three years of high school science in 1996, as compared to 45% in 1990, or an increase of 10 percentage points.

- ***Middle grades mathematics and science.*** First-year algebra courses were taken by over 20% of grade 8 students in nine states in 1996. Nationally, 15% of grade 8 students took algebra courses and 17% took pre-algebra courses. General science courses were taken by almost 40% of grade 7 and 8 students, 29% took life science, and 15% took earth science.

Policy Issue: Are minority students increasing their participation in higher-level mathematics and science? Is there a gender gap in mathematics and science?

- ***Race/ethnicity and higher-level math and science.*** Course enrollments in algebra 2 increased 20 percentage points for black, Hispanic, American Indian and white students from 1982 to 1994. Chemistry enrollments increased at a similar rate during the period. Asian students continue to have the highest of course enrollments. Eleven states are able to report math and science enrollments by student race/ethnicity, and significant differences in rates of course taking continue as of 1996.

- ***Student gender and higher-level math and science.*** More female students than males take three years of high school math and science in all 18 states reporting by gender in 1996.

Policy Issue: Are instructional practices consistent with national standards on teaching in mathematics and science?

- ***Discuss solutions to math problems with other students.*** In 12 states, over 50% of students in grade 4 discuss solutions to math problems in class once per week or more. Nationally, 48% of grade 4 students discuss problems with other students at least weekly. In grade 8, 36% of students discuss math problems almost every day, and 65% discuss math problems in class at least once per week.

- ***Use of calculators.*** In 1996, 49% of grade 8 students used calculators in math class almost every day. At grade 4, 34% of grade 4 students used calculators in math class once per week or more, as compared to 18% of students in 1992.

- ***Write about solving math problems.*** One-third of students in grade 8, nationally, write about how to

solve math problems once per week or more. Applying mathematics to real-life needs and problems is a major emphasis of NCTM standards. In three states, over 50% of grade 8 students write about math problems at least weekly.

Teacher Preparation and Supply

Policy Issue: What proportion of current teachers have knowledge and skills in their field at the level outlined by professional standards?

- ***Certified teachers in assigned field.*** Half the states had over 95% of high school science and math teachers certified in their assigned fields in 1996. One-fourth of the states had significant teacher shortages, with 10 to 20% of teachers not certified in their assigned field.

- ***Preparation of middle grades teachers.*** Nationally, 65% of math teachers in grades 7–8 are certified in mathematics, 17% are certified in elementary teaching, and 18% are not certified in their assigned field.

- ***Professional development on NCTM standards.*** Forty percent of grade 4 teachers and 65% of grade 8 math teachers reported participating in professional development activities aimed at implementing the mathematics standards during 1995–96.

- ***Sixteen or more hours professional development in mathematics.*** In 12 states, over 55% of grade 8 mathematics teachers received 16 hours or more of professional development in teaching mathematics during 1995–96.

- ***Minority teachers in mathematics and science.*** Southeastern states, California, and Hawaii have the highest proportion of minority teachers as compared to the student population. However, in most states, the number of minority teachers in high school math and science is less than one-third the proportion of students that are from minority groups. The numbers of minority teachers in mathematics and science increased slightly from 1990 to 1996.

- ***Female teachers of high school mathematics and science.*** The number of women teaching math and science has significantly increased since 1990. For example, 54% of mathematics teachers in grades 9–12 are now women, and 43% of chemistry teachers are women.

Conditions for Teaching

Policy Issue: How many students are teachers assigned to teach? To what extent are there adequate resources and materials for quality teaching?

- ***Student/teacher ratio.*** In high school mathematics, 6 states have student/teacher ratios of over 125 to 1, while 10 states have ratios of less than 100 to 1. In high school chemistry, 6 states have student/teacher ratios of over 125 to 1, and 13 states have ratios of less than 100 to 1.

- ***Class size.*** In high school mathematics, the average number of students per class varies across the states from 18 students per class to 28 students per class. Science classes in high schools vary by state from an average of 18 students per class to 29 students per class.

- ***Use of computers in math and science classes.*** In 35% of grade 4 classrooms one computer is available for mathematics and science instruction, 29% of classrooms have two or more computers available, and only 6% have no computers available.

In cooperation with the state departments of education, federal agencies, and professional organizations, the Council of Chief State School Officers (CCSSO) has developed a system of state indicators of the quality of science and mathematics education in public schools. The present report is the fourth in a series of biennial reports on state indicators. The reports are primarily intended for use by policymakers and educators.

The design, management, and reporting of indicators has been supported by the National Science Foundation (NSF) since the project was initiated in 1986. The state departments of education make major contributions to the system through advice on selection of indicators, collecting and reporting data from schools, and disseminating the indicators within states. In selecting and reporting state indicators, we also consult with science and mathematics educators, education researchers, and statistical experts. The Council places high priority on advocating for improving the quality and comparability of assessments and data that can produce reliable indicators of the health of our elementary and secondary schools.

Why State Science and Mathematics Education Indicators?

The science and mathematics indicators developed by CCSSO and the states meet at least three kinds of interests expressed to us by policymakers and educators:

- Reliable, comparable indicators, by state, to assess progress toward the National Education Goals and state goals;
- A range of indicators and data to analyze the effects of state education policies and reform initiatives; and
- Measures of the quality of science and mathematics education that are useful to educators and policymakers to plan programs, identify problems, and recommend new initiatives.

Efforts to develop a system of national and state indicators of the quality of science and mathematics education began in the mid-1980s. Widely read reports on the condition of elementary and secondary education, including *A Nation at Risk* (National Commission on Excellence in Education, 1983) and *Educating Americans for the 21st Century* (National Science Board, 1983) helped spur national and state reform initiatives; these reports also increased attention on improving the quality and availability of information to monitor progress and report on current conditions.

> *"Reaching a new standard of excellence requires clear educational objectives, strong leadership and firm commitment at all levels. Goals must be set and press toward those goals assessed ... The Federal government should finance and maintain a national mechanism for measuring student achievement and participation [in mathematics, science and technology education] in a manner that allows national, state and local evaluation and comparison of educational progress."*
>
> – Educating Americans for the 21st Century (National Science Board, 1983)

A central reason for national and state cooperation toward a system of comparable state-level education indicators is that states establish much of the legal and policy structure for education. State leaders recognized that making major decisions about funding, programs, and standards requires high-quality information that is regularly and readily available.

In the 1980s, states initiated a broad set of education policy reforms, including increased course credit requirements for graduation (particularly in mathematics and science), higher standards for teacher preparation, teacher tests for certification, higher levels for teacher pay, state curriculum guidelines and frameworks, and new statewide student assessments [Blank & Dalkilic, 1992; Blank & Espenshade, 1988; National Governors' Association (NGA), 1986]. An initial motivation for the Council's system of science and mathematics indicators was to track these policy

changes over time and report statistical indicators to assist states in analyzing the relationship of policies and reforms to improvements in education quality. The National Education Goals, established in 1989, provided another incentive for state education indicators. CCSSO has worked with the National Education Goals Panel (NEGP) to share state data and develop indicators that will be broadly useful to national and state policymakers and educators.

Now, many states have placed a high priority on developing new state curriculum frameworks and standards for academic subjects that are the basis for state education improvements. In mathematics, the National Council of Teachers of Mathematics (NCTM) Curriculum and Evaluation Standards and Teaching Standards (1989, 1991) are reflected in new state curriculum frameworks and in state efforts toward implementing mathematics education reforms (Blank, et al., 1997; Blank & Pechman, 1995). In science, many states are developing new frameworks and standards using guidance from the American Association for Advancement of Science (AAAS) Benchmarks for Science Literacy (1993) and the NRC National Science Education Standards (National Research Council, 1995). State education representatives advised CCSSO that they are very interested in having indicators for science and mathematics education that will help them assess the progress of schools toward national and state standards.

The state indicators are also aimed at assisting state leaders and others in identifying state and national trends, planning and evaluating programs, and working on new initiatives. For example, the CCSSO indicators provide comparable state-level data to describe baseline conditions across 25 states involved with the NSF's Statewide Systemic Initiatives (SSI), and the science-math state indicators can help to track overall progress at the state level and provide comparisons among SSI states and other states. All state education agencies administer the federally-funded Eisenhower Science and Mathematics Program for teacher professional development, and these science-math state indicators meet the needs for assisting in planning and evaluating the Eisenhower program by providing state statistics on the demographic characteristics of the teaching force, rate of new teachers entering science and mathematics, the current preparation of teachers in their assigned fields, and trends in professional development of science and mathematics teachers.

The science and mathematics indicators have other practical applications. State administrators have used course enrollment data to analyze differences in the level of course taking in their states, as compared to states in their region and states with similar demographic characteristics. Policymakers have been able to compare the proportion of science and mathematics teachers with a degree in their teaching field with recommended and proposed standards for teacher preparation. Teacher educators have identified teacher shortages by science specialization and by gender and race to target teacher recruitment and professional development programs.

How Are State Indicators Selected? Are They Comparable and Reliable?

The CCSSO system of state education indicators is based on three premises:

- Indicators should reflect the needs of users of education data, particularly policymakers and educators. Each chapter is prefaced by key policy issues addressed by the indicators.

- Indicators should be selected with consideration and input from the providers of data, such as state data managers, districts, and schools. We continually evaluate the quality and reliability of data provided, and seek technical advice on analyzing and reporting indicators.

- Indicators should be informed by a research-based model of the education system, including state context, school processes and resources, and student outcomes; and selected indicators should be measured with valid, reliable data.

Initially, we designed a conceptual framework for the state science and mathematics indicators through meetings with an expert panel and state education representatives and by review of the research literature on indicators and science and mathematics education (Murnane & Raizen, 1988; National Science Board, 1983, 1993; National Study Panel on Education Indicators, 1991; NGA, 1986; Oakes, 1986, 1989; Porter, 1991; Shavelson, McDonnell, Oakes, & Carey 1987). Using this framework, we developed a list of desired, or ideal, science and mathematics indicators, organized in six categories: student outcomes, instructional time/participation, curriculum content, teacher quality, school conditions, and equity. A survey of states and analysis of existing national surveys provided the basis for determining data availability on desired indicators and the potential for new data collection for the indicators (CCSSO, 1988).

A key step was convening a task force of state science and mathematics specialists (data users) and data managers (providers), education researchers, and federal education staff to weigh the desired indicators against both the quality of available data and the feasibility of collecting and reporting data by state. After discussion and analysis, the group reached a consensus on a priority list of indicators that led to the first CCSSO report (Blank and Dalkilic, 1991). Subsequently, we have convened advisory panels representing educators, researchers, and state education leaders to review the state science and mathematics indicators and to recommend improvements in methods of reporting.

In the present report, we have continued to maintain two initial decisions about the method of analyzing and reporting state indicators. First, the CCSSO report does not add up or otherwise combine individual indicators, such as state rate of enrollment in advanced courses and average student achievement, to produce a composite score for a state. Reporting which states are "ahead" or "behind" other states is not a main purpose of the indicators (CCSSO, 1985). We encourage the use and interpretation of multiple indicators, which may be measuring different aspects of science and mathematics education. Second, this report provides no analysis of cause-and-effect relationships between indicators. The emphasis is on reporting variation and trends by state for individual indicators. Some sections refer to analyses that have been done, and we encourage further analysis of the data presented here. The indicators were selected by using a model of the educational system that helps educators identify factors that explain improvement in educational outcomes. See Blank (1993) for further information and elaboration on the process of selecting and developing state education indicators.

What Are the Sources of Data?

We used four primary sources of data to report the 1997 state science and mathematics indicators:

1. The National Assessment of Educational Progress (NAEP) assessments in mathematics and science, administered by the NCES, are used to report indicators of student achievement by state, and teachers questionnaires were used for data on teaching practices in mathematics and professional development of teachers.

2. Results from the Advanced Placement examinations, administered by The College Board, also provide indicators of student achievement.

3. The Schools and Staffing Survey is a source for state-representative data on teacher preparation and school conditions for science and mathematics. The Survey is conducted by NCES.

4. The Council collected aggregated data from state departments of education on indicators of course enrollment, teacher assignments and characteristics, teacher certification, and new teachers in math and science. The data were collected through state information systems, and reported to CCSSO using standard data categories.

Organization of the Report

The state indicators are outlined in the next four chapters of the report. Chapter 1 describes indicators of student achievement in mathematics and science, with an emphasis on achievement by student race/ethnicity and gender. Chapter 2 includes indicators of curriculum, instructional practices, and class time, with a focus on their relation to state policies and professional standards. Chapter 3 provides state indicators of the quality of preparation of teachers and trends in the supply of teachers. Chapter 4 has several indicators of conditions in schools for science and mathematics teaching. The Conclusions chapter provides an overview of the use of the state indicators to analyze education policies.

The Appendices provide detailed data and information by state. Appendix A has state policy information, student background data, and several indicators for urban school districts; Appendix B provides examples of NAEP mathematics and science assessment exercises; Appendix C gives details on data sources and computations; and Appendix D provides a directory of course definitions and titles.

- ◇ **Student Proficiency on NAEP**
- ◇ **Mathematics and Science Proficiency by Student Race/Ethnicity and Gender**
- ◇ **Students Taking Advanced Placement Examinations**

Student Proficiency on NAEP

POLICY ISSUES

- ◦ Is student achievement in mathematics and science improving, and how does achievement compare state to state?
- ◦ Are students learning challenging content in science and mathematics?
- ◦ Are schools improving the performance of all students?

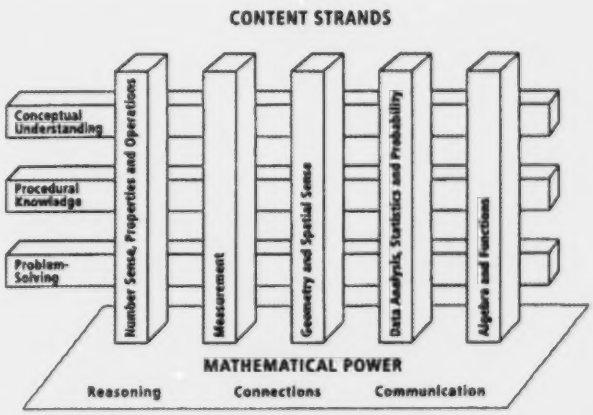
CCSSO strongly supports the development and use of state-level student assessments from NAEP as an indicator of student learning in mathematics and science. The Council led the "consensus planning process" that produced the Assessment Framework for the 1990 NAEP mathematics assessment, the first NAEP to report state-by-state scores, and the Framework for the 1996 NAEP Science Assessment, the first with state-level science results.

In the view of the Council, the NAEP assessment is the best source for student achievement indicators that are comparable state-to-state and adequately assess the range and depth of knowledge and student skills recommended by states and school districts. The NAEP mathematics assessment framework was strongly influenced by the mathematics standards developed by the National Council of Teachers of Mathematics (1989). The NAEP assessment results and supporting questionnaires from students and teachers are based on a sample of 2,000 students per state at each assessed grade. The data do not provide a way for states to analyze student achievement for each school and district. The results, however, are still extremely valuable as indicators. NAEP results provide a way to monitor state progress in student achievement; to assess education received by specific groups of students; and, very important, to determine the relationship of student achievement to characteristics of schools, classroom practices, and teachers, by state.

Mathematics Proficiency of Grade 8 Students

⇨ **From 1990 to 1996, 27 states made significant improvement in the percent of eighth grade students reaching the "Proficient" level on NAEP. Nationally, 23 percent of students scored at/above the Proficient level in 1996. Eight states had over 30 percent of students score at/above Proficient level in 1996.**

Our reporting on NAEP mathematics assessment results for 1996 and trends by state since 1990 focus on the percent of public school students that score at or above the Proficient level. The NAEP definition for the Proficient level is based on the Mathematical Framework for the 1996 Assessment which is graphically presented below.



Source: NAEP 1996 Mathematics Report Card for the Nation and the States, U.S. Department of Education.

BEST COPY AVAILABLE

The definition of "Proficient" according to the National Assessment Governing Board is:

> Eighth grade students performing at the Proficient level should apply mathematical concepts and procedures consistently to complex problems in the five NAEP content strands—Number Sense, Properties, and Operations; Measurement; Geometry and Spatial Sense; Data Analysis, Statistics and Probability; and Algebra and Functions (Reese, Miller, Mazzeo, & Dossey, 1997).

The NAEP Mathematics Assessment draws questions from the five framework mathematics Strands shown in the Framework. The assessment questions are categorized according to the domains of "mathematical abilities" and "mathematical power." Mathematical abilities "describes the nature of the knowledge or processes involved in successfully handling the task presented by the question—involving conceptual understanding, procedural knowledge or a combination of both in problem solving." Mathematical power refers to the students' ability "to reason, to communicate and to make connections of concepts and skills across mathematical strands, or from mathematics to other curricular areas" (Reese, et al., 1997, p. 2).

NAEP Assessments

NAEP results began to be reported using three achievement levels—Basic, Proficient, Advanced—in 1993 (Mullis, et al., 1993), and CCSSO began using the NAEP levels in reporting state mathematics and science indicators (Blank and Gruebel, 1993). The percentage of students at or above the Proficient level is defined as a key indicator by the National Education Goals Panel in its annual reporting on Goal 3 (1996). There are several reasons for our decision to use the NAEP levels. NAEP scores are more understandable and interpretable by the public and by educators when reported against standards for students expected knowledge and performance in a subject, e.g., mathematics, rather than being reported as a number on a scale, as in a norm-reference test, where the student score is only compared to the relative performance of other students, or students in other districts or states. States have moved toward use of achievement or performance levels for state assessment programs (Bond, Roeber, et al., 1997). State performance levels will be applied in reporting state assessments by the year 2000 under the new federal Title I law.

The NAEP assessments in mathematics and science are based on rigorous, challenging academic standards. They include different types of questions, including multiple choice items, short open-ended questions, and extended or "constructed response" questions in mathematics and "hands-on," laboratory tasks in science. The NAEP assessments are more demanding than the typical state test assessment, as shown by the percent of students at Proficient level on NAEP mathematics in comparison to the percent of students meeting a "proficient" or "mastery" level on most state assessments (NEGP, Report on State Assessments, 1996).

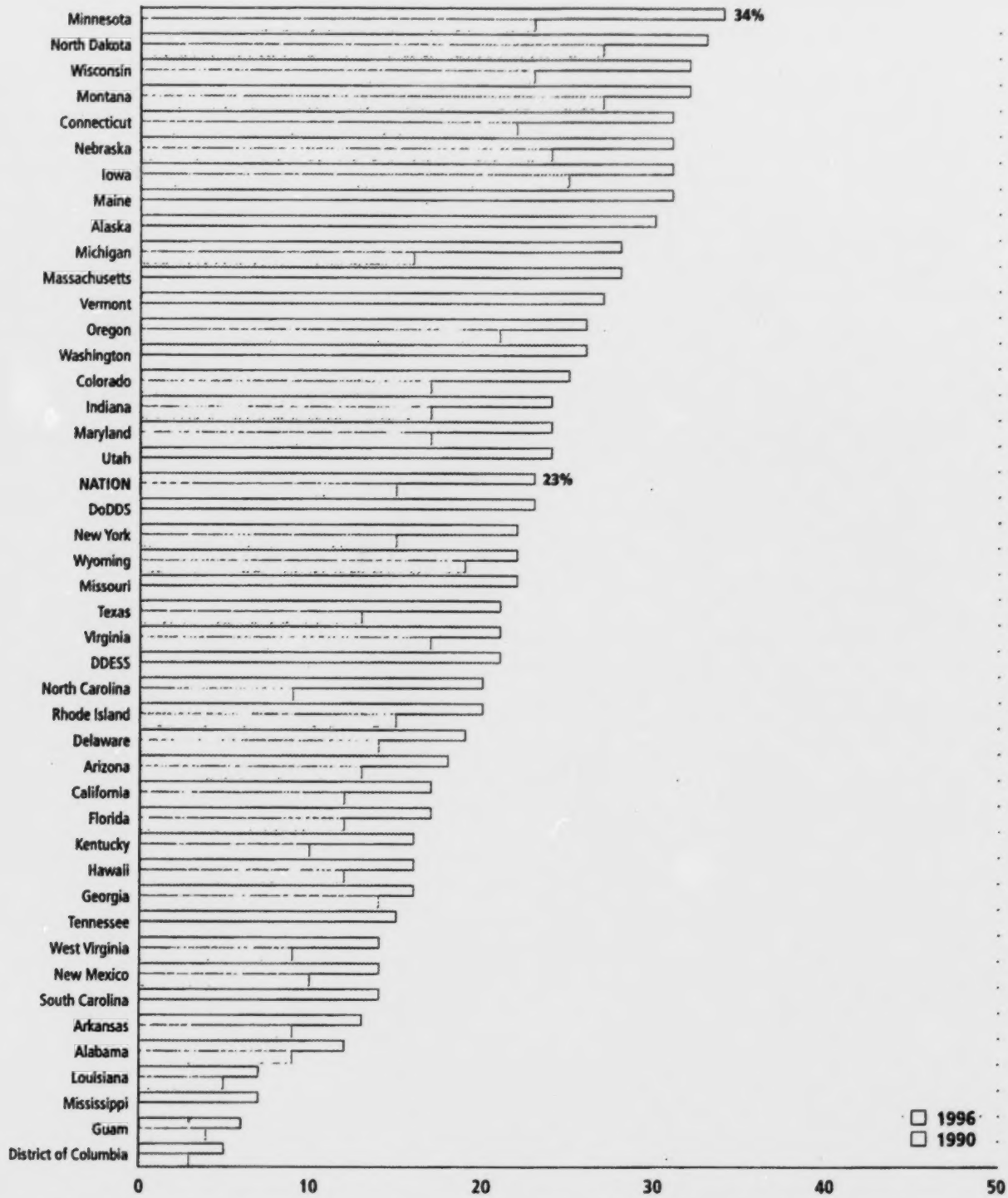
Summary of Grade 8 Results

The improvement in NAEP scores for grade 8 mathematics by state are displayed in Figure 1, showing the percent of students at/above Proficient for 1990 and 1996. Table 1 ranks states by the percent at/above the Proficient level. It gives change from 1990 to 1996, percent at the Advanced level and the average proficiency on the NAEP scale (0 to 500, for grades 4, 8, and 12).

- Almost all of the 40 states participating in 1996 NAEP showed improvement in grade 8 scores since 1990, with more than half showing a statistically significant improvement of +4 percentage points or more. Michigan, Minnesota, and North Carolina improved their percent of students at/above Proficient by 11 points in six years. Seven states made significant improvement in students at or above the Proficient level from 1992 to 1996.

- In 1996, the percent of students at or above the Proficient level varied from eight states at or above 30 percent (Connecticut, Iowa, Maine, Minnesota, Montana, Nebraska, North Dakota, and Wisconsin) to seven states below 15 percent (Mississippi, South Carolina, Louisiana, Alabama, Arkansas, West Virginia, New Mexico.)

Figure 1: Percent of Grade 8 Students At or Above Proficient Mathematics Level, 1990 to 1996 NAEP



Example: The percent of grade 8 students in Minnesota at or above the Proficient level increased 11 percentage points from 1990 to 1996.

Source: NAEP 1996 Mathematics Report Card for the Nation and the States, U.S. Department of Education.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Table 1: Mathematics Proficiency of Grade 8 Students, 1996 NAEP; Improvement 1990 to 1996

STATE	% at or Above Proficient Level, 1996	CHANGE 1990 TO 1996 % at or Above Proficient Level	% at Advanced Level, 1996	Average Proficiency, NAEP Scale 1996
Minnesota	34	+11 ◇	6 ◇	284
North Dakota	33	+6 ◇	4	284
Montana ▽	32	+5 ◇	5 ◇	283
Wisconsin ▽	32	+9 ◇	5 ◇	283
Connecticut	31	+9 ◇□	5	280
Iowa ▽	31	+6 ◇	4	284
Maine	31	+6 □('92)	6 □	284
Nebraska	31	+7 ◇	5 ◇□	283
Alaska ▽	30	–	7	278
Massachusetts	28	+5 ('92)	5	278
Michigan ▽	28	+12 ◇□	4 ◇	277
Vermont ▽	27	–	4	279
Oregon	26	+5 ◇	4	276
Washington	26	–	4	276
Colorado	25	+8 ◇	3	276
Indiana	24	+7 ◇	3	276
Maryland ▽	24	+7 ◇	5 ◇	270
Utah	24	+2 ('92)	3	277
DoDDS	23	–	3	275
NATION	**23**	**+8 ◇**	**4**	**271**
Missouri	22	+2 ('92)	2	273
New York ▽	22	+7 ◇	3	270
Wyoming	22	+3 ◇	2	275
DDESS	21	–	5	269
Texas	21	+8 ◇	3	270
Virginia	21	+4	3	270
North Carolina	20	+11 ◇□	3 ◇□	268
Rhode Island	20	+5 ◇□	3	269
Delaware	19	+5 ◇□	3	267
Arizona	18	+5 ◇	2	268
California	17	+5 ◇	3	263
Florida	17	+5 ◇	2	264
Georgia	16	+2	2	262
Hawaii	16	+4 ◇	2	262
Kentucky	16	+6 ◇	1	267
Tennessee	15	+3 ('92)	2	263
New Mexico	14	+4 ◇	2	262
South Carolina ▽	14	-1 ('92)	2	261
West Virginia	14	+5 ◇□	1	265
Arkansas ▽	13	+4 ◇	2	262
Alabama	12	+3	1	257
Louisiana	7	+2	0	252
Mississippi	7	+1 ('92)	0	250
Guam	6	+2	0	239
Dist. of Columbia	5	+2	1	233

Notes: ▽ Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.
◇ Significantly higher than 1990 NAEP mathematics proficiency at about the 95% confidence level.
□ Significantly higher than 1992 NAEP mathematics proficiency at about the 95% confidence level.
('92) = higher than 1992 NAEP, no data for 1990.
– Indicates jurisdiction did not participate in 1990 or 1992.
States not participating in 1996 NAEP mathematics: Idaho, Illinois, Kansas, Nevada, New Hampshire, New Jersey, Ohio, Oklahoma, Pennsylvania, South Dakota.

Source: NAEP 1996 Mathematics Report Card for the Nation and the States (see for standard errors of estimates).
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

- Nationally, 23 percent of grade 8 students scored at or above the Proficient level in 1996 (an improvement of eight points from 1990), 4 percent were at or above the Advanced level, while 61 percent of grade 8 students scored at or above the Basic level, and, 39 percent of students scored below the Basic level.

Mathematics Proficiency of Grade 4 Students

⇨ **From 1992 to 1996, only seven states made significant improvement in the percent of fourth grade students reaching the proficient level on NAEP. Nationally, 20 percent of students scored at/above the Proficient level for grade 4. Six states had 25 percent of students at/above Proficient level in 1996.**

The improvement in NAEP scores for grade 4 students in mathematics by state are displayed in Figure 2, showing the percent of students at/above Proficient for 1992 and 1996.

Table 2 gives the scores by state according to the percent at/above Proficient. It shows the change over four years, the percent at/above Basic and Advanced levels, and the average proficiency on the NAEP scale (0 to 500).

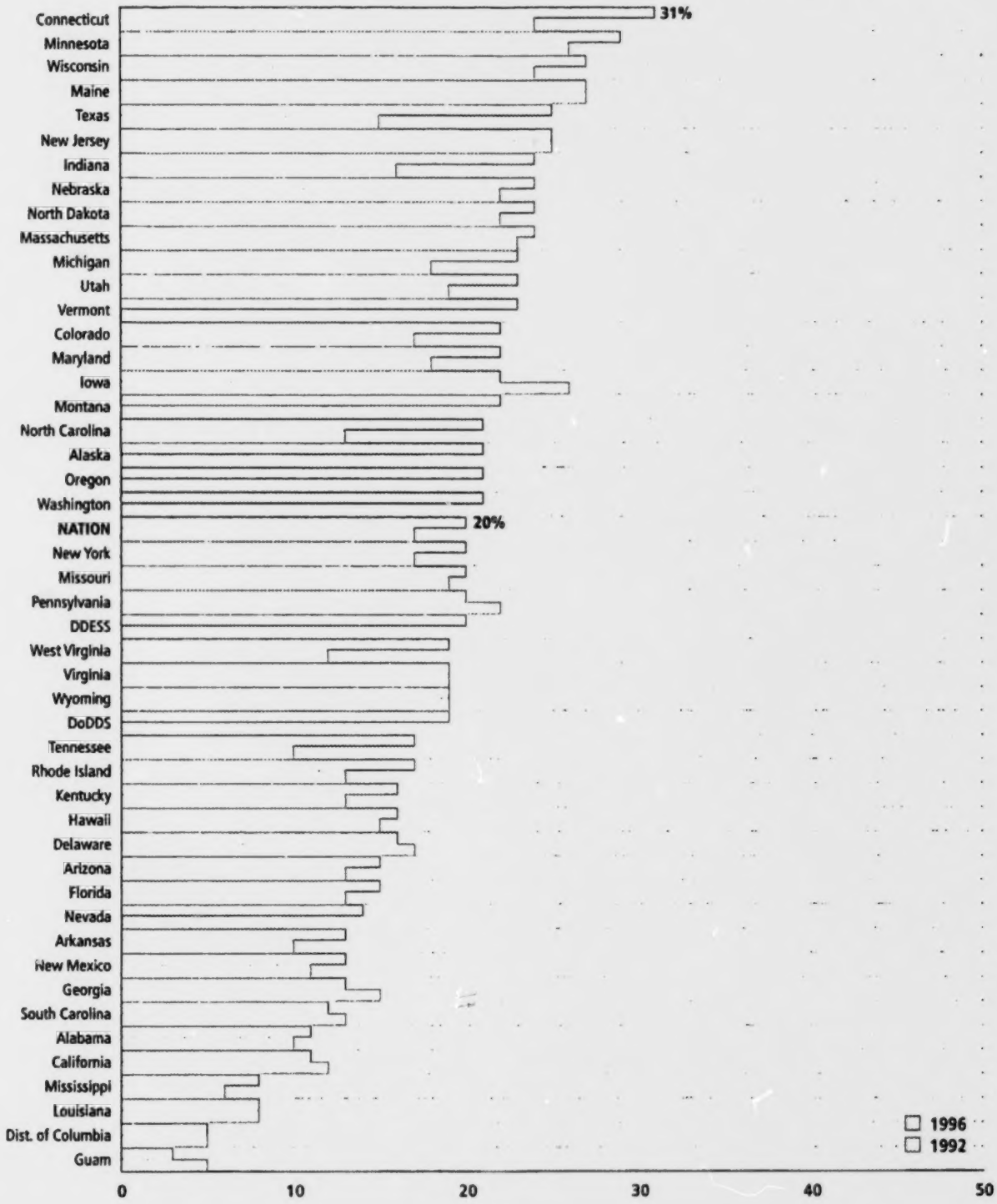
Summary of Grade 4 Results

- Twenty-three (of 43) states had a higher percent of grade 4 students at/above Proficient level on 1996 NAEP mathematics assessment than in 1992. Seven states showed improvement that was statistically significant (over four percentage points)—Colorado, Connecticut, Indiana, North Carolina, Tennessee, Texas, and West Virginia.
- Nationally, 20 percent of 4th graders were at or above the Proficient level, which represents improvement of 3 percentage points from 1992. States with 25 percent or more of grade 4 students at/above Proficient were Connecticut, Maine, Minnesota, New Jersey, Texas, and Wisconsin.
- Basic Level—Ten states had 70 percent or more of their grade 4 students at or above the Basic level on NAEP 1996 Mathematics. Nationally, 62 percent of 4th grade students were at/above Basic level, and 38 percent of students were below Basic.

The NAEP scores for Mathematics can be disaggregated by content strands in the mathematics assessment framework. The averages by content areas are available from CCSSO, the national report card (Reese, et al., 1997), or State NAEP reports (a report on each participating state). The scores are disaggregated for grades 4 and 8 mathematics according to: Numbers/Operations, Measurement, Statistics/Probability, Algebra/Functions, and Geometry.

The NAEP results in these tables and graphs show a statistical distribution of where states are in relation to other states and the nation, but it is difficult to get an idea of what mathematics students at a given level can actually do. Sample exercises in Appendix B illustrate the mathematics content and skills of students represented by the NAEP scores and levels. The 1996 sample exercises indicate the overall percentage of students scoring well on the problem and the percentage for students at or above the Proficient level.

Figure 2: Percent of Students in Grade 4 At or Above Proficient Mathematics Level, 1992 to 1996 NAEP



Source: NAEP 1996 Mathematics Report Card for the Nation and the States, U.S. Department of Education.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Table 2: Mathematics Proficiency of Grade 4 Students, 1996 NAEP; Improvement 1992 to 1996

STATE	% at or Above Proficient Level, 1996	CHANGE 1992 TO 1996 % at or Above Proficient Level	% at or Above Basic Level, 1996	% at Advanced Level, 1996	Average Proficiency, 1996
Connecticut	31	+7 □	75 □	3	232
Minnesota	29	+3	76	3	232
Maine	27	0	75	3	232
Wisconsin	27	+3	74	3	231
New Jersey ▽	25	0	68	3	227
Texas	25	+10 □	69 □	3 □	229
Indiana	24	+8 □	72 □	2	229
Massachusetts	24	+1	71	2	229
Nebraska	24	+2	70	2	228
North Dakota	24	+2	75	2	231
Michigan ▽	23	+5	68 □	2	226
Utah	23	+4	69	2	227
Vermont ▽	23	—	67	3	225
Colorado	22	+5 □	67 □	2	226
Iowa ▽	22	-4	74	1	229
Maryland	22	+4	59	3	221
Montana ▽	22	—	71	1	228
Alaska ▽	21	—	65	2	224
North Carolina	21	+8 □	64 □	2	224
Oregon	21	—	65	2	223
Washington	21	—	67	1	225
DDESS	20	—	64	2	224
Missouri	20	+1	66	1	225
NATION	**20**	**+3**	**62**	**2**	**222**
New York ▽	20	+3	64 □	2	223
Pennsylvania ▽	20	-2	68	1	226
DoDDS	19	—	64	1	223
Virginia	19	0	62	2	223
West Virginia	19	+7 □	63 □	2	223
Wyoming	19	0	64	1	223
Rhode Island	17	+4	61	1	220
Tennessee	17	+7 □	58 □	1	219
Delaware	16	-1	54	1	215
Hawaii	16	+1	53	2	215
Kentucky	16	+3	60 □	1	220
Arizona	15	+2	57	1	218
Florida	15	+2	55	1	216
Nevada ▽	14	–	57	1	218
Arkansas ▽	13	+3	54	1	216
Georgia	13	-2	53	1	215
New Mexico	13	+2	51	1	214
South Carolina ▽	12	-1	48	1	213
Alabama	11	+1	48	1	212
California	11	-1	46	1	209
Louisiana	8	0	44	0	209
Mississippi	8	+2	42 □	0	208
Dist. of Columbia	5	0	20 □	1	187
Guam	3	-2	23	0	188

Notes: ▽ Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.

□ Significantly higher than 1992 NAEP mathematics proficiency at about the 95% confidence level.

— Indicates jurisdiction did not participate in 1992.

States not participating in 1996 NAEP mathematics: Idaho, Illinois, Kansas, New Hampshire, Ohio, Oklahoma, South Dakota.

Source: NAEP 1996 Mathematics Report Card for the Nation and the States (see for standard errors of estimates).

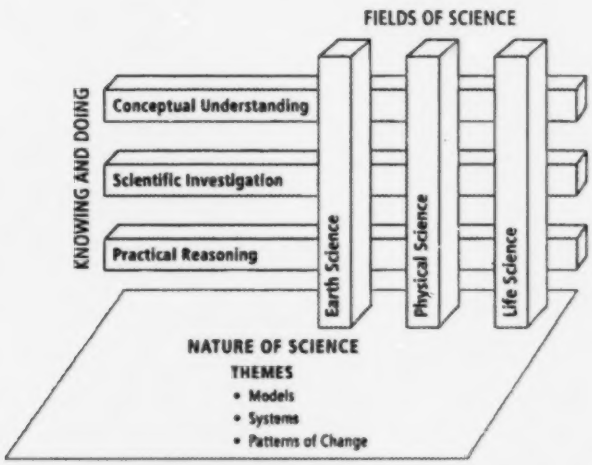
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Science Proficiency of Grade 8 Students

In 1996, the first state-level NAEP science assessment was conducted for grade 8 students, and the first NAEP Report Card with state data was released by NCES in May 1997 (O'Sullivan, Reese, Mazzeo, 1997). The NAEP science assessment was based on a new assessment framework. Half of the assessment time for the 1996 grade 8 science NAEP involved hands-on or constructed response exercises. The assessment changed significantly from earlier NAEP science exams, although national trends on NAEP are being maintained.

The science assessment framework, shown graphically below, included six content strands.

Science Framework for the 1996 Assessment



Source: Adapted from the National Assessment Governing Board's Science Framework for the 1996 National Assessment of Educational Progress.

In mathematics, we have focused on reporting and interpreting the NAEP results according to percent of students meeting NAEP achievement levels. However, for science, the achievement levels were still in the final processes of refinement when the 1996 Science Report was released. The only state-level results available for this publication were the grade 8 scale scores, shown in Table 3. The results are reported in three groups of states—states with student averages significantly above the national average, states scoring near

Table 3: Science Proficiency of Grade 8 Students, 1996 NAEP

STATE	Average Scale Score
Performed Above the National Average	
Maine	163
North Dakota	162
Montana ▽	162
Wisconsin ▽	160
Minnesota	159
Iowa ▽	158
Wyoming	158
Nebraska	157
Vermont ▽	157
Massachusetts	157
Utah	156
Connecticut	155
DoDDS	155
Oregon	155
Colorado	155
Michigan ▽	153
Indiana	153
DDESS	153
Alaska ▽	153
Performed At or Around the National Average	
Missouri	151
Washington	150
Virginia	149
Rhode Island	149
NATION	**148**
Kentucky	147
West Virginia	147
North Carolina	147
New York ▽	146
Maryland ▽	145
Texas	145
Arizona	145
Performed Below the National Average	
Arkansas ▽	144
Tennessee	143
Florida	142
Georgia	142
Delaware	142
New Mexico	141
Alabama	139
South Carolina ▽	139
California	138
Hawaii	135
Mississippi	133
Louisiana	132
Guam	120
Dist. of Columbia	113

Note: ▽ Indicates that the jurisdiction did not satisfy one or more of the guidelines for school participation rates. NAEP scale scores from 0 to 300 are specific to grade.

Source: NAEP 1996 Science Report Card, U.S. Department of Education.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

the national average, and states below the average. For 1996, the NAEP scale is 0 to 300. Scores from grades 4, 8, and 12 are reported on separate scales. The national average for the grade 8 scale is 148.

⇨ **Seventeen states, Defense Dependents Schools, and Defense Domestic Schools had science scale scores significantly above the national average. The scores in these states ranged from 153 (Alaska, Michigan, Indiana) to 163 (Maine).**

⇨ **Eleven states scored at or around the national average, from Missouri (151) to Maryland, Texas, Arizona (145); and the remaining states were significantly below the national average from Louisiana (132) to Arkansas (144).**

To give readers a better picture of what grade 8 students who score well on NAEP know and can do in science, we have included several release exercises from the 1996 assessment in Appendix B. Also in the Appendix is a graphic showing types of items students got correct if they were at different points on the NAEP scale. The example exercises are accompanied by the scores for students on the exercise. Readers can also get an idea of the types of problems that students work with on the NAEP science exam.

NAEP Link to TIMSS Scores

NCES is currently completing a linking project for NAEP and the Third International Mathematics and Science Study (TIMSS) results. The mathematics and science proficiency of students in each state as demonstrated on 1996 NAEP will be statistically correlated with student scores on TIMSS. The latter test was conducted in 1994–1995 in over 41 countries around the world. The project results available in Fall 1997 will give valid comparisons of states and nations proficiency in math and science.

Mathematics and Science Proficiency by Student Race/Ethnicity and Gender

A high priority for the Council's science and mathematics indicators is reporting on trends in equity in educational opportunity, conditions, and outcomes. One approach to indicators of equity in math and science education is disaggregating state averages according to differences in students' race/ethnicity and gender.

Minority-White Disparity by State

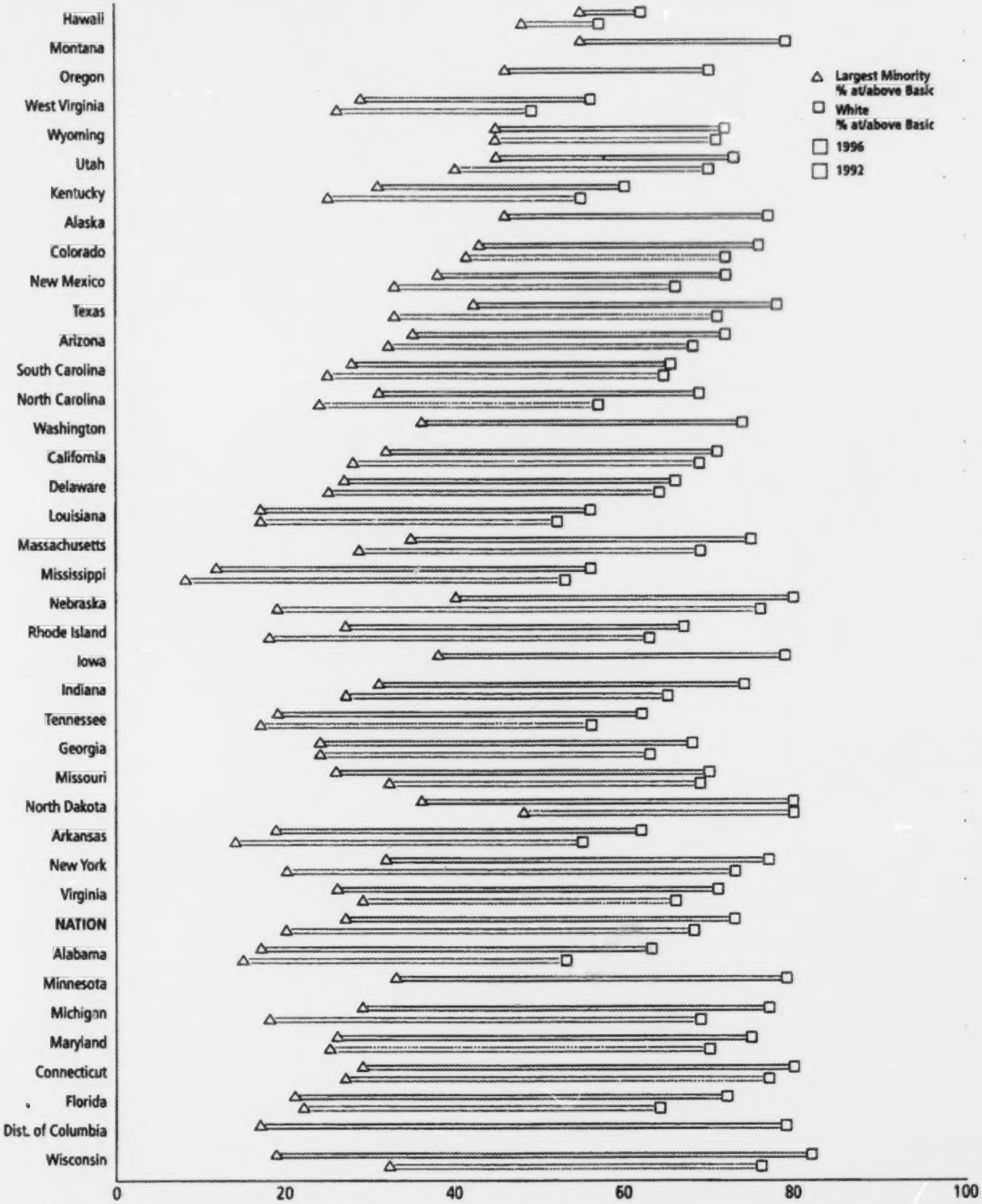
⇨ **Only nine states reduced the disparity in Mathematics performance of grade 8 students between scores for the largest minority group and those for white students from 1992 to 1996. For the nation, the white-black difference in percent of grade 8 students at/above Basic declined by two percentage points over four years.**

Figure 3 graphically shows the disparity between the percent of white students at/above the Basic level on NAEP mathematics at grade 8 and the percent for the largest minority group in each state. For example, the disparity in 1996 for Maryland is 49 percentage points—the difference between 75 percent of white Maryland students at or above the Basic level and 26 percent for black students. The disparity between white and black students in New York is 45 percentage points, a decline in the difference from 53 percentage points in 1992. Each state's disparity can be compared with the disparity for the nation of 46 points between whites (73 percent) at or above Basic and the percentage for black students (27 percent).

Table 4 provides state-by-state percentages of students scoring at/above the Basic level on grade 8 NAEP mathematics for five race/ethnic groups. The table also shows the 1996 disparity between white students and the largest minority group in percent at/above Basic level, and the change in the minority-white disparity (in percentage points) from 1992 to 1996 (negative number indicates a decline in disparity).

The disparity indicator is not aimed at attributing the race or ethnicity of minority students for their lower

Figure 3: Disparity in Basic Mathematics Level Between Largest Minority Group and White Students, Grade 8, 1992 to 1996 NAEP



Example: In Maryland, 26% of largest minority group (black) at/above Basic level in '96 and 25% in '92; 75% of whites at/above Basic in '96 and 70% in '92.

Source: NAEP 1996 Mathematics Report Card for the Nation and the States (see for standard errors of estimates).

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Table 4: Race/Ethnic Differences in Basic Mathematics Level for Grade 8 Students, 1996 NAEP

	PERCENT AT OR ABOVE BASIC LEVEL, 1996						
	White	Black	Hispanic	Asian/ Pacific Islander	American Indian	Disparity White-Minority 1996	CHANGE in Disparity 1992 to '96
NATION	**73%**	**27% □**	**37%**	**58%**	**50%**	**46**	**-2**
STATE							
Alabama	63	17 □	23	*	*	46	+8
Alaska ▽	77	*	44	65	45 □	31	—
Arizona	72	34	35 □	*	40	37	+1
Arkansas ▽	62	17 □	*	*	*	45	+4
California	71	25	32 □	67	*	39	-2
Colorado	76	40	43 □	76	*	33	+2
Connecticut	80	29 □	37	70	*	51	+1
Delaware	66	27 □	36	*	*	39	0
Dist. of Columbia	79	17 □	16	*	*	62	—
DDESS	74	39	52	*	*	—	—
DoDDS	77	39	59	72	*	—	—
Florida	72	21 □	39	*	*	51	+9
Georgia	68	24 □	36	*	*	44	+5
Guam	*	*	16	31 □	*	*	—
Hawaii	62	*	33	55 □	*	7	-2
Indiana	74	31 □	44	*	*	43	+5
Iowa ▽	79	38 □	57	*	*	41	—
Kentucky	60	31 □	*	*	*	29	-1
Louisiana	56	17 □	24	*	*	39	+4
Maine	78	*	*	*	* □	*	—
Maryland ▽	75	26 □	36	86	*	49	+4
Massachusetts	75	35 □	26	67	*	40	0
Michigan ▽	77	29 □	37	*	*	48	-3
Minnesota	79	33 □	49	60	*	46	—
Mississippi	56	16 □	11	*	*	40	+1
Missouri	70	26 □	48	*	*	44	0
Montana ▽	79	*	52	*	55 □	24	—
Nebraska	80	40 □	44	*	*	40	-17
New Mexico	72	*	38 □	*	37	34	+1
New York ▽	77	32 □	30	75	*	45	-8
North Carolina	69	31 □	41	*	*	38	+5
North Dakota	80	*	55	*	36 □	44	+12
Oregon	70	*	46 □	78	46	24	—
Rhode Island	67	31	27 □	56	*	40	-5
South Carolina ▽	65	28 □	26	*	*	37	-2
Tennessee	62	19 □	32	*	*	43	+4
Texas	78	31	42 □	86	*	36	2
Utah	73	*	45 □	62	*	28	2
Vermont ▽	74	*	*	*	*	*	—
Virginia	71	26 □	44	74	*	45	+8
Washington	74	27	36 □	66	45	38	—
West Virginia	56	29 □	30	*	*	27	+4
Wisconsin ▽	82	19 □	45	*	*	63	+19
Wyoming	72	*	45 □	*	35	27	+1

Notes: ▽ Indicates that the jurisdiction did not satisfy one or more of the guidelines for school participation rates (1996).

□ Race/ethnic minority group with largest enrollment.

* Sample size insufficient to permit reliable estimates.

For change in disparity: "-" means *decline* in disparity; "+" means *increase* in disparity.

— Data not available.

Source: NAEP 1996 Mathematics Report Card for the Nation and the States (see for standard errors of estimates). .

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

performance (generally) on the NAEP assessment. Rather, we aim to highlight the need for improvement of schools to help raise the performance of all students, especially minority students from economically disadvantaged backgrounds. The minority-white disparity measure for analyzing race/ethnic differences in student achievement is based on the percent of students at or above the Basic level on NAEP because the state percentages for each race/ethnic group are often too small for useful comparisons.

Student performance at "Basic level" does *not* mean students are meeting a minimum level of expectations for the subject (as in the "minimum competency" tests used by states in the 1970s). The definition of "Basic" set by the Governing Board is:

> Eighth-grade students performing at the Basic level should exhibit evidence of conceptual and procedural understanding in the five NAEP content strands. This level of performance signifies an understanding of arithmetic operations—including estimation—on whole numbers, decimals, fractions, and percents. (Reese, Miller, Mazzeo, & Dossey, 1997).

Summary on Race/Ethnic Disparity:

- All states have a significant disparity between the scores for white students and scores for the largest minority group (1996: low in Hawaii at 7 points, high in Wisconsin at 63 points).

- The national difference between white and black students in percent at/above Basic level is 46 percentage points (73% vs. 27%). The disparity for white and Hispanic students is 36 points, and for white vs. American Indian students the disparity is 23 points.

- Scores for the largest minority group in each state increased in 24 states between 1992 and 1996. In most of these states the scores for white students increased at about the same rate, thus the overall disparity for the nation declined only two percentage points.

- The only states to close the disparity gap more than two percentage points over four years were Michigan (-3), Nebraska (-17), New York (-8), and Rhode Island (-5).

Within State vs. Between State Variation in NAEP Scores

The differences in mathematics proficiency by race/ethnicity point out an important fact about variation in NAEP proficiency scores. Differences in student math proficiency are much greater within each state than are the differences between the states. For example, in Minnesota, the difference in scores between students at the 10th percentile versus students at the 90th percentile is 86 points on the 0 to 500 NAEP scale (240 vs. 326), (Reese, Miller, Mazzeo, & Dossey, 1997) whereas the difference between the average proficiency of Minnesota students and the average proficiency of Mississippi students is 34 points (284 average score Minnesota, 250 average score in Mississippi). This difference in state averages does indicate that grade 8 students in the highest scoring state are performing in mathematics at about three grades higher than the lowest state (grade 8 average = 271 scale points, grade 4 average = 222, or a difference of about 12 scale points per grade).

National Trends on NAEP by Race/Ethnicity and Gender: 1982–1996, 1990–1996

NCES reports two national trends for NAEP mathematics and science scores due to the change in the NAEP Assessment Frameworks and change in the methods of assessment starting in 1990.

A) *Long-Term NAEP Trends on Mathematics and Science.* The original NAEP trend analysis, going back to its inception in 1969, is based on a core set of multiple-choice test items and the initial assessment framework that tracks the degree of change in students mathematics and science knowledge over almost 30 years. CCSSO has chosen to analyze NAEP trends from 1982 to 1996 to track change in student performance following the education reforms and policy initiatives developed at state and national levels in response to *A Nation At Risk*, the highly influential report of the National Commission on Excellence in Education (1983).

B) *New Main NAEP Assessment in Mathematics.* In 1990, a new NAEP mathematics framework was applied in developing the assessment and open-ended questions were introduced to the assessment. In 1992, extended constructed response questions were added to the math assessment. NCES and NAGB established a new trend line in 1990 for mathematics. In the 1996 NAEP Report Card for Mathematics trends are analyzed for the new main NAEP over the six-year period.

CCSSO has decided to use both the "long-term" and "main" NAEP trend analyses, and to report the trends by student race/ethnic and gender differences. This analysis approach allows readers to consider the degree of improvement of student performance for all populations of students in our public schools.

NAEP Race/Ethnic Trends

⇨ *Long-term trends, 1982 to 1994:* Minority and white students show significant improvement in math and science. The figures on the following table show black and Hispanic students' proficiency at all ages rose significantly—for example, black students at age 9 improved 17 points (195 to 212) and Hispanic students' age 9 scores improved 6 points (204 to 210). Science scores for black students at age 17 improved dramatically over 12 years (235 to 257), as compared to 13 points for white 17-year-olds.

A 20-point improvement on NAEP is substantial—it can be interpreted as the equivalent of an improvement of almost two years of school (given the differences in average for 9- vs. 13-year-olds). Scores for white students improved also during the period, so substantial differences in performance remain on the original NAEP trends assessment. Improved scores on the NAEP trend assessment shows that U.S. public school students are performing better than they were in the early 1980s in mathematics and science. This finding presents solid evidence to the contrary of some public opinion and media discussion about the poor performance, or lack of improvement, in the basics in math and science in public schools.

Trends in Average Mathematics and Science Proficiency by Race/Ethnicity, NAEP 1982 and 1994

Mathematics	1982	1994
Black		
Age 9	195	212*
Age 13	240	252*
Age 17	272	286*
Hispanic		
Age 9	204	210
Age 13	252	256
Age 17	277	291*
White		
Age 9	224	237*
Age 13	274	281*
Age 17	304	312*
Science		
Black		
Age 9	187	201*
Age 13	217	224
Age 17	235	257*
Hispanic		
Age 9	189	201
Age 13	226	232
Age 17	249	261
White		
Age 9	229	240*
Age 13	257	267*
Age 17	293	306*

* Statistically significant difference from 1982.

NAEP trends reported on a scale of 0 to 500; trend scores are reported by age groups rather than grades.

Source: Campbell et al., 1996.

⇨ *Main NAEP Mathematics, 1990–1996.* On the new NAEP math assessment, all groups have improved since 1990. Black and Hispanic students made significant improvements at grade 4 and grade 12 (e.g., 11 points improvement for grade 12 Hispanics). White students made significant improvements in scores at all three grade levels (e.g., 12 point improvement in grade 8 whites).

Main NAEP Trends in Mathematics Proficiency by Race/Ethnicity, NAEP 1990 to 1996

	1990	1996
Black		
Grade 4	189	200*
Grade 8	238	243
Grade 12	268	280*
Hispanic		
Grade 4	198	206*
Grade 8	244	251
Grade 12	276	287*
White		
Grade 4	220	232*
Grade 8	270	282*
Grade 12	301	311*

* Statistically significant difference from 1990.

Source: Reese et al., 1996.

NAEP Trends by Gender

⇨ ***Long-term NAEP, 1982 to 1994.*** The analysis of trends by student gender show no differences in average mathematics and science proficiency at age 9 and age 13. The average proficiency for males is slightly higher than females at the 12th grade in mathematics. There is little change in NAEP math scores by gender over the period.

The science NAEP results show that in 1994 females continue to score slightly lower than males at age levels 13 and 17, but age 9 scores are almost the same. Females have made statistically significant improvement in science performance at grade 13 since 1987. The difference in NAEP science scores for males and females at age 17 is the equivalent of about one year of high school.

Trends in Average Mathematics and Science Proficiency by Gender, NAEP 1982 to 1994

	1982	1994
Mathematics		
Male		
Age 9	217	232*
Age 13	269	276*
Age 17	302	309*
Female		
Age 9	221	230*
Age 13	268	273*
Age 17	296	304*
Science		
Male		
Age 9	221	232*
Age 13	256	259
Age 17	292	300*
Female		
Age 9	221	230*
Age 13	245	254*
Age 17	275	289*

* Statistically significant difference from 1982.

Source: Campbell et al., 1996.

⇨ ***Main NAEP, Mathematics 1990–96.*** On the new version of NAEP beginning in 1990, gender differences on math scores have almost disappeared. There is less difference in grade 12 scores between males and females on the new main NAEP than there is on the long-term trend NAEP (reported above).

Main NAEP Trends in Mathematics Proficiency by Gender, NAEP 1990 to 1996

	1990	1996
Male		
Grade 4	214	226*
Grade 8	263	272*
Grade 12	297	305*
Female		
Grade 4	213	222*
Grade 8	262	272*
Grade 12	291	303*

* Statistically significant difference from 1990.

Source: Reese et al., 1997.

Students Taking Advanced Placement Examinations

⇨ **Eight states increased the percent of 12th grade students taking AP Mathematics exams by at least two percentage points from 1992 to 1996.**

⇨ **Ten states increased the percent of students taking AP Science exams by at least two percentage points from 1994 to 1996.**

⇨ **Nationally, 5 percent of high school 12th graders took AP Mathematics exams in calculus, 6 percent took Science exams in biology, chemistry or physics in 1996.**

Each year the College Board offers Advanced Placement (AP) examinations in a range of academic subjects for public and private school students in each state. If students receive a composite score of 3, 4, or 5 they can receive a college credit for the subject. Many high school students enroll in courses that follow the AP curriculum. The number of high school students in a state taking AP examinations and the proportion who receive a qualifying (passing) score, provide an indicator of high-level student achievement. Caution should be used in interpreting this indicator since AP exams represent a voluntary group of students, and states and districts may differ significantly in how students are enrolled in AP courses and apply to take the exams.

Table 5: Students Taking Advanced Placement Examinations in Mathematics and Science, 1996, and Trends 1992 to 1996

STATE	AP CALCULUS			AP SCIENCE*		
	% of Grade 12 Students Taking Exam	% Receiving Quaiified Score	Change '92–'96 % of Grade 12	% of Grade 12 Students Taking Exam	% Receiving Qualified Score	Change '94–'96 % of Grade 12
Dist. of Columbia	11%	77%	+3%	15%	81%	+2%
New York	9	62	+1	13	67	+3
New Jersey	8	68	+2	11	68	+2
Maryland	8	68	+2	9	65	+2
Massachusetts	8	71	+2	9	69	+2
South Carolina	7	49	+1	7	54	+1
Utah	7	73	+1	9	68	0
Delaware	7	76	+1	10	75	+2
Virginia	7	61	+1	7	61	+1
New Hampshire	7	71	+2	6	64	+2
North Carolina	7	54	+3	7	50	+1
Hawaii	7	76	+1	9	65	+2
Connecticut	7	74	+2	9	71	+2
California	6	66	+1	8	63	+2
Florida	6	57	+1	8	49	+2
Illinois	6	70	+1	7	71	+1
Indiana	6	39	+2	7	31	+1
Colorado	5	71	+1	5	67	+1
NATION	5	64	+1	6	62	+1
Pennsylvania	4	62	+1	5	61	+1
Michigan	4	69	+1	5	65	+1
Minnesota	4	62	+2	2	65	+1
Georgia	4	63	+1	4	63	-2
Maine	4	57	+1	4	60	+1
Vermont	4	58	0	6	67	+1
Alaska	4	71	+1	4	60	+1
Wisconsin	4	68	+2	3	62	+1
Rhode Island	4	63	0	5	66	+1
Ohio	4	66	+1	4	63	+1
New Mexico	4	61	+1	3	56	0
Tennessee	3	64	0	4	66	+1
Texas	3	64	+1	3	60	+1
Kentucky	3	53	+1	3	44	0
Wyoming	3	66	+1	1	60	0
Arizona	3	65	0	4	52	0
Nevada	3	63	+1	4	44	+1
Alabama	3	51	+1	3	51	0
Washington	3	70	+1	2	70	0
West Virginia	2	54	0	2	44	0
Oklahoma	2	64	0	2	57	0
Iowa	2	75	+1	1	73	0
Idaho	2	73	0	2	74	0
Missouri	2	72	+1	2	70	0
Oregon	2	73	0	2	67	0
Mississippi	2	42	+1	2	51	+1
Kansas	2	70	+1	1	70	0
Arkansas	2	56	+1	2	50	+1
South Dakota	2	58	+2	2	45	+1
Montana	2	60	+1	2	56	+1
Nebraska	1	65	0	1	65	0
Louisiana	1	55	0	1	61	0
North Dakota	1	77	0	1	58	0

Example: 8% of grade 12 students in New Jersey took the AP Calculus exam in 1996, 68% of those students received 3, 4, 5 score; in 1992, 6% of grade 12 students took the exam.

Note: State totals include public and private schools. * AP Science = students taking AP Biology, Chemistry, or Physics.

Source: The College Board (1996). Advanced Placement Program, National and 50 States Summary Reports.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Table 5 provides state-by-state data on the percentage of 12th grade students (public and private schools) in each state that took 1996 AP exams in Mathematics/calculus and in Science fields of biology, chemistry, or physics; the percentage of 1996 exam-takers who receive a qualifying score; and the percentage points increase/decrease in AP exams from 1992 to 96 (the period reported by state by CCSSO).

- From 8 to 11 percent of grade 12 students took the 1996 Math/calculus AP exam in Massachusetts, Maryland, New Jersey, New York, and the District of Columbia;

- Over 8 percent of grade 12 students took a Science AP exam in DC, New York, New Jersey, Maryland, Massachusetts, Utah, Delaware, Hawaii, Connecticut, California, and Florida.

Nationally, the 5 percent of 12th grade students taking AP calculus in 1996 (total of 123,000 students), is an increase from 4 percent in 1992. In science, the 6 percent taking an AP exam in 1996 (total of 137,000), is an increase from 4 percent in 1992. These totals include both public and private schools. Nationally, 80 percent of AP exams in all subjects are taken by public school students. Please note that the percentage of 12th grade students is used for statistical comparison across states—AP exams are not limited to only 12th grade students.

Scores that qualified students for college credit were awarded to 64 percent of students, nationally, in Mathematics (calculus) and to 62 percent in Science (biology, chemistry, or physics). The state percentages for qualified scores in AP math varied from 39 percent of exam-takers (in Indiana, where 6 percent of 12th grade students took the exam) to 77 percent of exam-takers (in DC, where 11% took the exam, and North Dakota, where 1% took the exam).

AP Exams by Race/Ethnicity and Gender

An important feature of this indicator is measuring progress in minority and female participation in AP exams, as shown in Table 6. The percentage female among students taking AP Calculus varied from 33 percent in Oregon to 52 percent in Alabama and South Carolina. In 1996, nationally 45 percent of AP math exam-takers were female, which is an increase of two percentage points from 1992. The percentage female taking AP Science exams varied from 36 percent in Nebraska to 56 percent in Wyoming and 55 percent in Vermont. Nationally, 45 percent of students taking AP Science exams in 1996 were female.

The math and science totals by state are reported in Table 6 according to the percentage of exam-takers who were from race/ethnic minority groups. Nationally, 25 percent of students taking AP Calculus exams were minority students, and 26 percent taking AP science exams were minority students. These statistics show a slight decline in math and no change in science from 1992 for minority student participation.

States with more than 30 percent minority participation in AP Calculus were: Hawaii, California, Texas, New Jersey, and Florida. Texas, New Mexico, and Oklahoma increased the percent minority in AP math by four percentage points. In eight states, the percent minority taking the AP math declined by more than two percentage points.

States with over 30 percent minority participation in AP Science were: Hawaii, California, Maryland, Texas, New Jersey, Florida, and Illinois. Texas, Florida, Connecticut, and Alaska had the largest increases in minority participation. In 10 states, minority participation declined by more than two points.

Race/ethnic data for each minority group by state are available from CCSSO on diskette or hard copy.

Table 6: Minority and Female Students Taking Advanced Placement Examinations in Mathematics and Science, 1996; Change 1992 to 1996 in Minority Participation

	AP CALCULUS			AP SCIENCE		
STATE	% Minority of Students Taking AP Calculus	Change '92–'96 % Minority	% Female of Students Taking Exam	% Minority of Students Taking AP Science	Change '94–'96 % Minority	% Female of Students Taking Exam
Hawaii	77%	+1%	48%	75%	-2%	47%
California	53	0	45	49	0	44
Texas	36	+5	46	36	+16	43
New Jersey	30	+3	44	30	+1	44
Florida	30	+1	46	32	+4	46
New Mexico	29	+4	44	26	-4	43
Dist. of Columbia	27	-2	42	25	-10	45
New York	26	-1	47	25	-8	47
NATION	25	-1	45	26	0	45
Maryland	24	-1	45	31	0	43
Illinois	24	-3	46	28	-1	44
Nevada	22	-2	41	20	-1	46
Oklahoma	22	+4	41	24	+2	38
Louisiana	22	-2	44	23	0	44
Virginia	21	+1	46	26	+2	50
Washington	21	+1	42	17	-1	45
Arizona	20	-2	43	22	0	46
Alabama	19	0	52	20	-5	49
Georgia	19	-1	48	24	-2	47
South Carolina	19	0	52	19	+3	54
Delaware	18	0	48	15	-4	45
Connecticut	17	+1	45	28	+9	45
Massachusetts	17	-1	44	16	0	42
Tennessee	17	-1	45	19	-1	46
Missouri	16	0	40	16	+3	43
Michigan	15	-1	43	18	-2	44
Colorado	14	-8	43	14	-2	44
Mississippi	14	+1	48	16	-2	46
Pennsylvania	14	-1	44	13	-1	45
Arkansas	14	-1	43	5	-8	44
North Carolina	14	0	51	16	-3	53
Kansas	13	-2	42	18	-7	37
Oregon	13	0	33	15	-1	40
Alaska	13	-3	38	16	+8	46
New Hampshire	13	-1	42	11	-2	40
Ohio	12	-3	43	15	-2	46
Rhode Island	10	-8	42	12	+1	40
Indiana	9	-2	44	10	-2	47
Minnesota	8	-1	45	10	-1	43
West Virginia	8	-3	40	7	-2	47
Kentucky	8	+2	50	8	+2	48
Wisconsin	7	0	43	8	-2	43
Vermont	7	0	47	4	-5	55
Iowa	7	0	40	10	0	37
Nebraska	6	-1	39	7	-1	36
North Dakota	6	-3	44	8	+1	53
Wyoming	5	+1	47	5	+2	56
Idaho	5	0	38	4	-2	45
Utah	5	-1	40	5	0	40
Montana	4	-3	46	2	-1	48
Maine	3	-2	41	3	+1	42
South Dakota	1	-2	49	4	-3	54

Note: State totals include public and private schools. Minority students = sum of black, Hispanic, Asian/Pacific Islander, American Indian, etc.
% AP Science = Students taking AP Biology, Chemistry, or Physics.

Source: The College Board (1996). Advanced Placement Program, National and 50 States Summary Reports.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

- **Course Enrollments in High School Mathematics and Science**
- **State Policies and Course Enrollment Trends**
- **Middle Grades Course Enrollments**
- **Instructional Practices in Mathematics and Science**
- **Class Time on Mathematics and Science**

State policy makers and science and math educators need to know about curriculum content and instructional practices in schools. A system of education indicators typically focuses first on student achievement as the primary measure of the outcome of schooling. Then, educators, policy makers, and the public would like to be able to understand differences in student achievement in terms of how and what students are taught. These kinds of indicators could help to inform efforts to develop teachers' knowledge and skills, and to improve the design and delivery of mathematics and science curriculum.

Four types of state indicators are likely to be most useful to our target audiences. In the following paragraphs we describe these types of indicators and then present state indicators being reported for 1995–96.

1. *Curriculum content in mathematics and science taught in classrooms.*

In the 1990s almost all states have developed new content standards for core academic subjects, including science and math (CCSSO/State Education Assessment Center, 1996). As these standards are being applied in developing curriculum, professional development strategies, and new approaches to student assessment, educators and policy makers are likely to need consistent, reliable information on subject content of what is taught in math and science and what students are expected to know and be able to do. National sample surveys, (e.g., NAEP, NELS88) and some state assessments have included curriculum surveys with teachers.

The most comprehensive and detailed data on "implemented curriculum" have been collected and analyzed in international studies. The Third International Mathematics and Science Study (TIMSS) measured student achievement in 41 countries based on mathematics and science assessment frameworks developed by consensus of the participating countries (NCES, 1996a, 1997a). The study also included surveys with teachers and students that had a goal of collecting reliable, comparable data on the "implemented curriculum" in math and science classrooms across the participating countries. Teachers were asked to complete a survey with questions on teacher preparation, teaching practices, and amount of time spent on curriculum topics. The data show variation by country in the content of the actual curriculum that is taught, as well as the degree of variation in curriculum within a country. For example, the results will show the proportion of class time in grade 8 mathematics that teachers report classes spend on algebra and functions versus geometry versus numbers and numerical operations versus measurement. Grade 8 mathematics can be analyzed by 30 mathematics content topics or categories.

Previous international studies using this design, such as Second International Mathematics Study have proven extremely valuable for analyzing differences in the curriculum content and instruction received by students both between countries and within the U.S. (for example, see McKnight, et. al., 1987). Data on the implemented curriculum from TIMSS were not available for this report, but they are scheduled to be released by the National Center for Education Statistics in Fall 1997. States could collect and report data on implemented curriculum in mathematics and science with questionnaires for teachers similar to those used in the TIMSS surveys.

A similar approach to measuring curriculum in science classrooms is being used by CCSSO with a multi-state collaborative on science assessments (Martin, Blank, & Smithson, 1996). The CCSSO surveys are available to states and districts to collect and report data on science curriculum and instructional practices at elementary, middle, and high school levels, and the approach is being adapted for mathematics.

2. *Secondary student course enrollments in mathematics and science.*

CCSSO aggregates data from state information systems on student course enrollments for grades 7–12. These data provide an important indicator for several reasons. Research on patterns of student achievement in math and science has consistently shown that the amount of time in instruction and number and level of secondary courses students take is strongly related to achievement (Husen, 1967; Jones, L.R., Mullis, Raizen, Weiss, & Weston, 1992; Jones, L.V., Davenport, Bryson, Bekhuis, & Zwick, 1986; Rock, Braun, & Rosenbaum, 1985; Sebring, 1987; Walberg, 1984). Analyses of recent NAEP results show that high mathematics proficiency is best explained by the level of mathematics courses students have completed (Mullis et al., 1993, Reese, et al, 1997). We also know that instructional time and course taking in math and science vary widely across U.S. schools, and that they are correlated with the socioeconomic status of students in our schools (Goodlad, 1984; Horn & Hafner, 1992; McKnight et al., 1987; Oakes, 1990; Weiss, 1994). New research on secondary curricula show that schools with highly differentiated secondary course offerings do most harm in holding back disadvantaged students (Lee, Bryk & Smith, 1993.)

States have an interest in determining the proportion of students that progress through the secondary science and mathematics curriculums to different course levels—for example, algebra 2, trigonometry, precalculus or chemistry, physics, advanced courses or AP math and science—because they indicate the proportion of students being offered more challenging content that meets high state content standards. Course taking patterns can be analyzed by state policies on high school graduation requirements, which have shown significant increases since the mid-1980s. The course enrollments by state also are useful for tracking how states and schools are progressing in offering opportunities for science and math to students from all race/ethnic groups and for female and male students.

3. *Instructional Practices in Math and Science Classrooms.*

States have found the data from NAEP teacher and student questionnaires that accompany the mathematics and science assessments to be very useful in providing state-by-state information on instructional practices in their states. For example, data on use of math manipulative or calculators in math classes can be analyzed by characteristics of schools and teachers. For many state users, NAEP achievement results become most valuable when analyzed with information on instruction, resources, and teachers. NAEP data can be used to simply describe current instructional practices in a state or for varying characteristics of classrooms and teachers, based on a standard set of items and consistent procedures, and NAEP data can be analyzed to determine the relationship of instructional practices to achievement.

4. *Class Time on Mathematics and Science.*

A very basic indicator of curriculum and instruction is the amount of time that teachers spend in teaching a subject. At the elementary level, there is wide variation by school, district, and state on how time is used in teaching various subjects. Sample surveys with teachers, such as Schools and Staffing Survey conducted by NCES, can provide basic data on differences in time devoted to mathematics and science and to other subjects.

Course Enrollments in High School Mathematics and Science

POLICY ISSUES

- What proportion of students take challenging subject content in mathematics and science, indicated by course enrollments in high school curriculum?
- What are trends in mathematics and science course taking for students, reported by gender and race/ethnicity?

Students Taking Higher-Level Mathematics

⇨ **Nationally, 62 percent of students took three years of high school mathematics in 1996, as compared to 49 percent in 1990, an increase of 13 percentage points in six years.**

⇨ **Seven states had over 75 percent of high school students take three years of high school math in 1996, as indicated by algebra 2 or integrated math 3 enrollments.**

Many states have set three years of high school mathematics as a requirement for graduation, following the recommendations from *A Nation at Risk* (National Commission on Excellence in Education, 1983). Figure 4 reports the percentage of high school students in each state that take three high school mathematics courses by graduation, based on data from the 1995–96 school year. States are ordered by the percentage of students taking *algebra 2 or integrated math 3* by graduation (generally, the third year of mathematics in the high school curriculum). The percentage of students reaching three years of high school mathematics varies from 78 percent (Utah and Nebraska) to less than 50 percent (California, Delaware, and Hawaii).

Figure 4 also shows the change from 1990 to 1996 by state in the percent of students taking *algebra 2 or integrated math 3* in high school. The national average is an increase of 13 percentage points. Twelve states increased enrollments in algebra 2/integrated math 3 by 15 percentage points or more: Utah, Nebraska, Mississippi, Missouri, Kentucky, Texas, West Virginia, North Carolina, DC, Iowa, Arkansas, and Ohio.

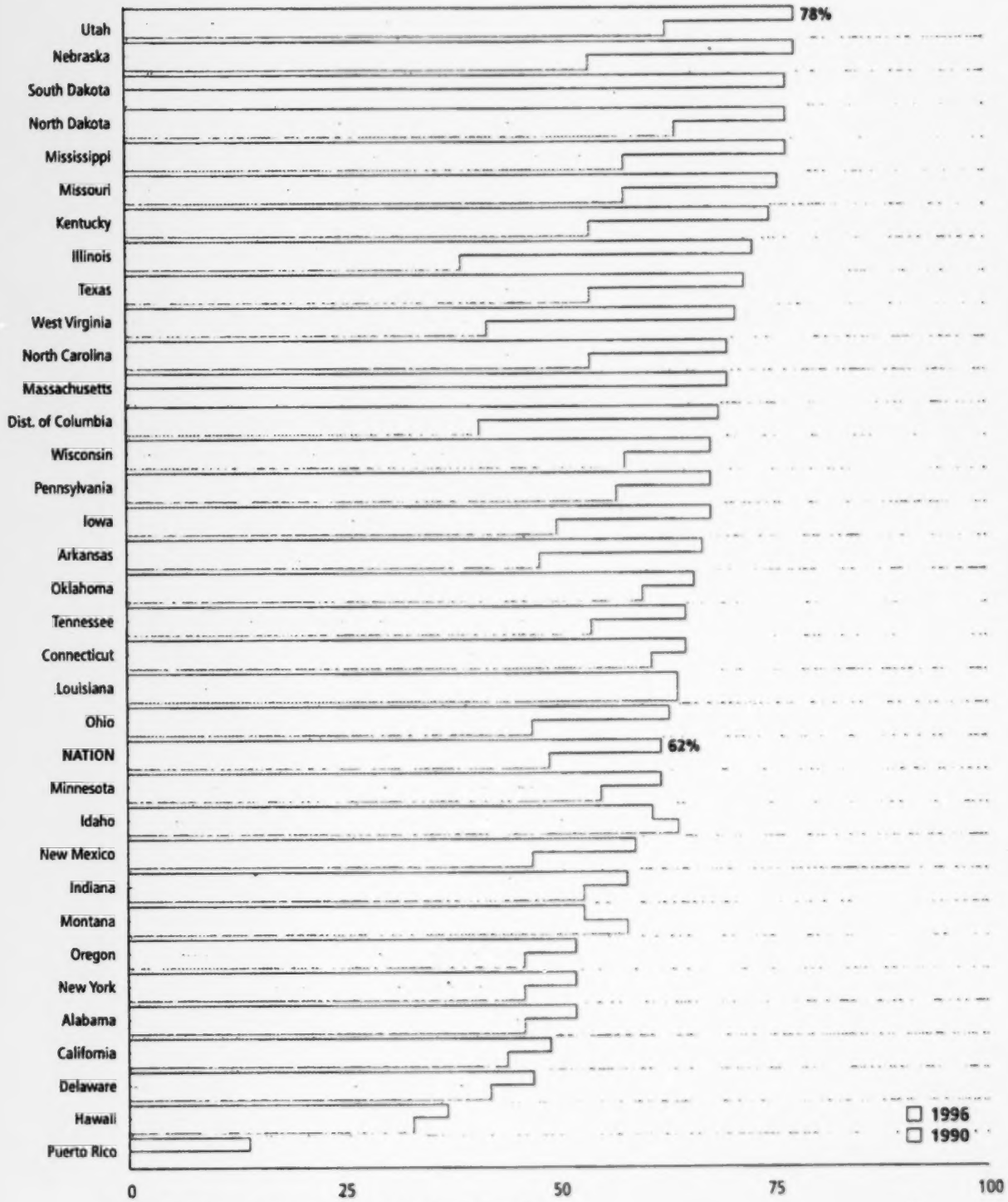
Trends are shown for only those states reporting data for 1990 and 1996. States were excluded that changed their course codes or definitions.

Table 7 reports the percent of high school students taking each of five levels of mathematics by graduation. The states are ranked by the percent taking algebra 2 or integrated math 3 (level 3). Nationally, 95 percent or more students take *first-year algebra or integrated mathematics 1* by the time they graduate, and most states have enrollments over 95 percent. The state percentages for algebra 1/integrated mathematics 1 include enrollments during high school, as well as in grade 8.

The percentage of students taking *geometry or integrated math 2* varies by state from 95 percent (North Carolina, District of Columbia, Wisconsin) to less than 51 percent (Hawaii), with the national average at 72 percent. Two years of high school mathematics has been shown to be an important door to success in college, particularly for minority students. Analysis of college attendance and completion rates show that taking two years of high school mathematics is a strong predictor of whether minority students complete a college degree (Pelavin & Kane, 1990). From 1992 to 1996, the percent of students taking geometry increased from 61 to 72 percent.

Many states and districts established a goal of increasing the proportion of students that take algebra 1, or integrated mathematics 1, as well as more advanced high school mathematics courses, to meet their graduation requirements. One approach states have used in working toward this goal is developing state curriculum frameworks for districts and schools to use in planning and organizing the mathematics curriculum. States also set specific policies. As of 1996, Georgia, Louisiana, Mississippi, North Carolina, and Texas required that students pass algebra 1, and Arkansas requires algebra 1 or applied math 1. See Appendix A for graduation requirements by subject in each state.

Figure 4: Percent of High School Students Taking Algebra 2/Math Level 3 by Graduation, 1990 to 1996



Source: State Departments of Education, Data on Public Schools, 1995–96.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Table 7: Students Taking Higher-Level Mathematics Courses by Graduation, 1996

STATE	% Algebra 2/ Integrated Math 3 (Level 3) (%)	% Algebra 1/ Integrated Math 1 (Level 1) (%)	% Geometry/ Integrated Math 2 (Level 2) (%)	% Trigonometry/ Precalculus (Level 4) (%)	% Calculus/ AP Calculus (Level 5) (%)
Utah	78	95+	93	52	18
Nebraska	78	95+	90	48	13
Mississippi	77	95+	75	40	6
South Dakota	77	94	84	39	8
North Dakota	77	95+	82	52	6
Missouri	76	95+	71	32	13
Kentucky	75	95+	72	39	9
Illinois	73	83	79	44	12
Texas	72	95+	73	39	9
West Virginia	71	95+	85	51	9
North Carolina	70	95+	95+	69	13
Massachusetts	70	95+	75	47	17
Dist. of Columbia	69	95+	95+	22	6
Pennsylvania	68	95+	70	61	18
Wisconsin	68	95+	95+	46	15
Iowa	68	89	77	38	12
Arkansas	67	95+	72	31	7
Oklahoma	66	95+	67	28	9
Tennessee	65	95+	69	23	6
Connecticut	65	95+	72	41	18
Louisiana	64	95+	88	29	6
Ohio	63	95+	74	38	12
NATION	**62**	**95+**	**72**	**37**	**12**
Minnesota	62	81	68	41	14
Idaho	61	95+	66	29	12
New Mexico	59	95+	56	24	8
Indiana	58	91	67	34	16
Montana	53	95+	72	39	7
New York	52	95+	68	31	14
Oregon	52	88	61	28	8
Alabama	52	73	55	21	9
California	49	95+	57	25	10
Delaware	47	91	58	41	12
Hawaii	37	68	51	19	4
Puerto Rico	14	84	58	7	—
Alaska	—	—	—	—	—
Arizona	—	—	—	—	—
Colorado	—	—	—	—	—
Florida	—	—	—	—	—
Georgia	—	—	—	—	—
Kansas	—	—	—	—	—
Maine	—	—	—	—	—
Maryland	—	—	—	—	—
Michigan	—	—	—	—	—
Nevada	—	—	—	—	—
New Hampshire	—	—	—	—	—
New Jersey	—	—	—	—	—
Rhode Island	—	—	—	—	—
South Carolina	—	—	—	—	—
Vermont	—	—	—	—	—
Virginia	—	—	—	—	—
Washington	—	—	—	—	—
Wyoming	—	—	—	—	—

Example: 52% of Utah students took Trigonometry/Precalculus (4th Year of high school math) prior to graduation, based on data from 1995–96 school year.

Notes: — Data not available. Illinois, Minnesota, Texas: 1994–95 data. Each state percent is a statistical estimate of course taking of public high school students by the time they graduate based on the total course enrollment in grades 9–12 in fall 1994 divided by the estimated number of students in a grade cohort during four years of high school. The statistical estimating method is imprecise above 95%. Nation = Percent of all public high school students estimated to take each course, including imputation for nonreporting states *(see Appendix C)*. Algebra 1 percentages include grade 8 Algebra 1, except Illinois, Iowa, and Pennsylvania.

Source: State Departments of Education, Data on Public Schools, 1995–96.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

BEST COPY AVAILABLE

Integrated Mathematics and Science

Integrated mathematics and science curricula at the high school level have been developed in several states. Some districts and states have begun to use the integrated mathematics curriculum texts and materials that are modeled after the NCTM mathematics curriculum standards (1989), and the development was supported by NSF. Integrated courses help teachers organize curriculum and instructional strategies that bring together key concepts often taught in separate high school courses, such as algebra, geometry, and functions.

Table 8 highlights the proportion of students taking integrated math, often in place of first-year algebra, in the 17 states that collected detailed data on this course. In 1995–96 school year, over 15 percent of grade 9 students took integrated math 1 (vs. algebra 1) in New York, District of Columbia, Montana, California, and Louisiana. Integrated math as the initial high school course is predominant in the state of New York (85%).

Mathematics Enrollments by Grade

Many educators and policy makers are interested in tracking the specific grade at which high school students take certain math and science courses. Enrollments in two levels of high school math courses are reported by grade in Table 9—algebra 1 or integrated math 1, and, algebra 2 or integrated math 3. Seventeen states were able to report their enrollment data by the grade at which students took the course in 1995–96. The data show divergent patterns in *algebra 1/integrated math 1*. For example, DC, Indiana, New York, North Dakota, and Wisconsin enroll over 60 percent of students in this course level in 9th grade. Other states tend to have more students taking algebra 1/integrated math 1 through grades 9, 10, and 11, such as Kentucky, Missouri, North Carolina, Texas, and Utah.

The largest enrollments in *algebra 2/integrated math 3* (indicator of three years of high school math) are in grade 11, in all states. Most states do have from 15 to 25 percent of students taking this course level in grade 10, and many students also take their third year of math in grade 12.

Table 8: Integrated Mathematics Course Enrollments, 1996

STATE	Integrated Math 1 % of grade 9
California	18
Connecticut	9
Dist. of Columbia	40
Idaho	2
Indiana	1
Kentucky	4
Louisiana	16
Massachusetts	6
Minnesota	1
Montana	24
New Mexico	7
New York	85
Ohio	7
Oregon	15
Pennsylvania	5
South Dakota	3
West Virginia	4

Notes: Minnesota, 1994–95 data. New York students enrolled in grades 9, 10 or 11.

Source: State Departments of Education, Data on Public Schools, 1995–96; NCES, CCD Fall Membership 1994.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Trend in Students Taking General or Consumer Mathematics in High School

The NCTM mathematics education *Standards* (1989) recommend that all high school students receive challenging mathematics content in areas of algebra, functions, geometry, trigonometry, and statistics, as well as skills in problem solving, communication, and reasoning. Recently, state and local policies and curriculum guidance to schools have aimed at increasing the proportion of high school students beginning in the 9th grade with algebra (or integrated math 1), with the goal of increasing the proportion of students progressing to higher-level math in grades 10–12. These policies have also aimed to decrease general math and consumer math courses in the high school curriculum.

Table 9: Students Taking Algebra 1/Integrated Math 1 and Algebra 2/Integrated Math 3 as a Percent of Students in Each High School Grade, 1996

	ALGEBRA 1/INTEGRATED MATH 1				ALGEBRA 2/INTEGRATED MATH 3			
STATE	% Grade 9	% Grade 10	% Grade 11	% Grade 12	% Grade 9	% Grade 10	% Grade 11	% Grade 12
Alabama	37	15	5	1	2	14	29	8
California	48	28	6	2	3	10	28	6
Connecticut	43	17	8	3	2	17	33	13
Dist. of Columbia	64	18	11	5	5	17	33	14
Hawaii	18	23	15	7	1	10	16	12
Idaho	54	20	4	1	3	18	37	2
Indiana	64	13	3	1	3	20	31	3
Kentucky	42	21	16	7	5	21	25	24
Missouri	34	19	20	22	15	18	21	20
New York	70	16	3	0.5	0.3	8	41	4
North Carolina	35	30	15	7	1	22	30	17
North Dakota	67	18	4	2	2	24	43	9
Puerto Rico	7	59	13	7	0	6	4	4
Texas	70	34	14	5	2	19	36	17
Utah	42	27	9	3	6	27	30	10
West Virginia	41	21	9	3	4	27	27	12
Wisconsin	72	28	10	4	4	19	33	11

Note: Texas: 1994–95 data.

Source: State Departments of Education, Data on Public Schools, 1995–96; NCES, CCD Fall Membership 1994.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

The state indicators data allow us to track the effectiveness of efforts to move more students into courses with challenging content. States reported data to CCSSO on all courses taken by students in grades 7–12, including general math and applied math courses. The data were aggregated by course level using a common course taxonomy to determine trends in math at lower versus higher levels.

A graph in Appendix A shows the percentage of all high school students taking general math, consumer, or remedial math courses, computed as a percentage of all students enrolled in grades 9–12 in the 1995–96 school year compared to the 1989–90 school year. States are ordered from low to high on percentages taking *lower-level* math. The percentages enrolled in these courses as of 1996 vary from under 5 percent in Tennessee, North Carolina, Texas, and Mississippi to over 20 percent in Hawaii and Puerto Rico. Change in these enrollments can be examined for states that reported these data for 1989–90. States showing a decline in enrollments in general/consumer math of over 10 percentage points include Texas, District of Columbia, Kentucky, New Mexico, and California.

Nationally, just over 10 percent of high school students were taking general or consumer math during the 1995–96 school year, as compared to 19 percent of high school students six years ago.

Students Taking Higher-Level Science Courses

- **Nationally, 55 percent of students took three years of high school science in 1996, as compared to 45 percent in 1990, an increase of 10 percentage points in six years.**

- **Seven states had over 65 percent of high school students take three years of high school science, as indicated by chemistry enrollments in 1996.**

Figure 5 reports the percentage of high school students in each state that take three years of high school science courses by graduation, based on data from the 1995–96 school year. States are ordered by the percentage of students taking *chemistry 1* (generally, the third year of science in the high school curriculum). The percentage of students reaching this level of science varies from over 76 percent (e.g., Wisconsin, DC) to 39 percent (e.g., California). States over 65 percent are: Wisconsin, Maine, Kentucky, Iowa, Massachusetts, Pennsylvania, Arkansas.

Figure 5 also shows the change by state from 1990 to 1996 in students attaining three years of high school science. Twelve states increased enrollments in chemistry more than 12 percentage points over six years: Texas, Nebraska, West Virginia, Delaware, Arkansas, Pennsylvania, Kentucky, Maine, Wisconsin, and DC.

Table 10 shows the percent of high school students in each state that take courses in several levels of science by graduation: chemistry, physics, and biology. These percentages are based on data from the 1995–1996 school year. The states are ordered by the percent of students that take *chemistry* by graduation. It is possible for students to take three years of science without taking chemistry (e.g., two years of biology and one year of earth science); but as an indicator across states, course enrollment in chemistry is the indicator that is most consistent.

All states have a very high proportion of students taking first-year *biology* by graduation, and nationally over 95 percent of high school students take biology. In many states, the increase to two or three graduation requirements for science in the 1980s means that the typical student now takes an introductory science course, e.g., earth, physical, general, or integrated science, and a course in biology. In a few states, such as Mississippi, biology is the first science course in high school.

Physics enrollments vary by state from 56 percent in Maine, 42 percent in Arkansas, 39 percent in Pennsylvania to under 12 percent in Oklahoma and New Mexico. The national average is 24 percent of students taking physics by graduation, and this is an increase of four points from 20 percent in 1990. This percentage is an estimate of the proportion of students taking four years of high school science.

Figure 5: Percent of High School Students Taking Chemistry by Graduation, 1990 to 1996

Source: State Departments of Education, Data on Public Schools, 1995–96.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Table 10: Students Taking Higher-Level Science Courses by Graduation, 1996

STATE	Chemistry 1st Year (%)	Physics 1st Year (%)	Biology 1st Year (%)
Dist. of Columbia	78	27	95+
Wisconsin	76	35	95+
Maine	75	56	95+
Kentucky	68	20	95+
Iowa	68	32	95+
Massachusetts	67	37	95+
Pennsylvania	67	39	95+
Arkansas	65	42	95+
New York	64	32	95+
Delaware	64	23	95+
Connecticut	63	36	95+
Illinois	63	33	95+
North Carolina	62	20	95+
North Dakota	60	26	95+
West Virginia	60	16	55
Nebraska	59	31	95+
Mississippi	58	17	95+
Ohio	58	23	95+
Indiana	57	24	95+
Puerto Rico	56	26	80
NATION	**55**	**24**	**95+**
Texas	55	18	95+
Louisiana	54	25	95+
South Dakota	52	27	91
Tennessee	52	13	92
Minnesota	51	25	95+
Missouri	51	18	95+
Hawaii	51	28	95+
Montana	49	27	95+
Utah	47	31	95+
Alabama	45	14	95+
Idaho	41	15	95+
New Mexico	41	12	95+
Oklahoma	40	12	95+
Oregon	40	20	82
California	39	18	79
Alaska	—	—	—
Arizona	—	—	—
Colorado	—	—	—
Florida	—	—	—
Georgia	—	—	—
Kansas	—	—	—
Maryland	—	—	—
Michigan	—	—	—
Nevada	—	—	—
New Hampshire	—	—	—
New Jersey	—	—	—
Rhode Island	—	—	—
South Carolina	—	—	—
Vermont	—	—	—
Virginia	—	—	—
Washington	—	—	—
Wyoming	—	—	—

Example: 68% of Kentucky students took Chemistry (three years of high school science) prior to graduation, based on data from 1995–96 school year.

Notes: — Data not available. See Appendix C for computation of percentages. Illinois, Minnesota, Texas: 1994–95 data.

Source: State Departments of Education, Data on Public Schools, 1995–96.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Initial Science Courses in High School

Table 11 shows enrollments of high school science courses in earth science, physical science, general science, and integrated science. Not all students take these courses in grade 9, but this is a common pattern and using grade 9 enrollment as the denominator improves state comparisons. These data are useful to educators interested in tracking the patterns and trends in science course-taking across states. There are marked differences in course enrollments by state.

- *Earth Science:* The states of Arkansas, Montana, Idaho, and New York have over 60 percent of grade 9 students taking earth science.

- *Physical Science:* Alabama, Arkansas, Louisiana, Missouri, North Dakota, Oklahoma, South Dakota, and Texas have over 60 percent taking this initial course, and Arkansas has many students taking both earth science and physical science for science credits.

- *General Science:* Only Puerto Rico has more than 60 percent taking this course in high school. About half the states have over 15 percent of students taking this course in high school.

Several states now have a substantial percentage of students taking an integrated or coordinated science curriculum, often starting in grade 7 and continuing through grade 9 or 10. A *coordinated* science curriculum treats the disciplines of biology, chemistry, physics and earth/space science individually and equitably and focuses on an overarching idea in the sciences that can be explained in terms of all four disciplines. An *integrated* science curriculum intentionally blurs the traditional disciplinary lines and treats science as a whole, under the assumption that the disciplines should not be separated in the secondary curriculum (California Scope, Sequence & Coordination Project, 1995).

Integrated or coordinated science enrollments in 1996 included over 15 percent of students enrolled in grade 9 in West Virginia, Kentucky, Utah, Oregon, and California. In West Virginia the great majority of students take integrated science in grade 9 and in grade 10 or 11.

CCSSO has available on diskette additional, more detailed, disaggregation of science and math course enrollments by state, including enrollments in "general" versus "applied" biology, chemistry, and physics as well as enrollments by state in advanced/second year courses and advanced placement (AP) courses.

Science Enrollments by Grade

As with selected mathematics courses, CCSSO aggregated data from states on science course enrollments by specific grade at which high school students take a course. Enrollments in first-year biology are reported by grade in Table 12. Eighteen states were able to report their enrollment data by the grade at which students took the course in 1995–96. The data show divergent patterns in *first-year biology* course taking patterns. For example, Indiana enrolls two-thirds of students in biology in grade 9, and Texas, DC, Utah, Wisconsin, and New York have about one-third of students taking biology in grade 9. Idaho, North Dakota, California, and Hawaii have most students taking biology in grade 10, while Kentucky and Missouri schools enroll many students in biology across all four grades.

Table 11: Students Taking Earth Science, Physical Science, General Science, and Integrated Science as a Percent of Grade 9 Students, 1996

STATE	PERCENT OF GRADE 9 STUDENTS			
	Earth Science	Physical Science	General Science	Integrated or Coordinated Science
Alabama	2	67	5	—
Arkansas	83	80	0	—
California	9	31	10	18
Connecticut	40	25	24	4
Delaware	26	59	—	2
Dist. of Columbia	22	—	2	—
Hawaii	27	8	18	3
Idaho	63	36	5	—
Illinois	19	22	16	3
Indiana	28	22	10	3
Iowa	26	45	33	—
Kentucky	3	45	—	35
Louisiana	12	66	16	—
Maine	57	—	—	—
Massachusetts	28	31	12	7
Minnesota	10	40	—	3
Mississippi	2	34	1	—
Missouri	15	64	15	—
Montana	80	10	4	8
Nebraska	43	52	23	—
New Mexico	7	41	20	—
New York	67	8	9	5
North Carolina	39	77	—	—
North Dakota	3	106	—	—
Ohio	21	26	41	—
Oklahoma	4	69	6	—
Oregon	13	35	9	21
Pennsylvania	26	24	20	—
Puerto Rico	26	0.5	71	—
South Dakota	18	61	3	1
Tennessee	7	77	—	—
Texas	8	62	—	2
Utah	34	20	—	33
West Virginia	2	14	3	81
Wisconsin	26	58	21	—

Notes: — No students reported enrolled. Illinois, Minnesota, Texas: 1994–95 data.

Some students take these courses beyond grade 9. Most West Virginia students take Integrated Science in grade 9 and over 90% take Integrated Science in grades 10 or 11.

Source: State Departments of Education, Data on Public Schools, 1995–96; NCES, CCD Fall Membership 1994.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Table 12: Students Taking First-Year Biology as a Percent of Students in Each High School Grade, 1996

	BIOLOGY, 1ST YEAR			
STATE	% Grade 9	% Grade 10	% Grade 11	% Grade 12
Alabama	29	67	9	3
California	14	53	6	3
Connecticut	21	67	8	6
Dist. of Columbia	42	36	12	5
Hawaii	16	66	19	4
Idaho	7	86	13	6
Indiana	68	28	4	3
Kentucky	28	42	24	14
Missouri	24	32	20	22
New York	32	74	3	2
North Carolina	25	71	7	2
North Dakota	2	91	8	3
Ohio	30	54	12	7
Puerto Rico	0.5	61	17	4
Texas	41	46	9	4
Utah	37	57	21	11
West Virginia	2	45	5	3
Wisconsin	34	84	12	6

Note: Texas: 1994–95 data.

Source: State Departments of Education, Data on Public Schools, 1995–96; NCES, CCD Fall Membership 1994.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

State Policies and Course Enrollment Trends

POLICY ISSUES

- Have enrollments in higher-level courses increased since many states raised graduation requirements?
- Do states with policies setting higher course requirements for graduation have higher rates of course taking in science and mathematics?

Current efforts toward science and math reform are aimed at high standards for the content of what students know and can do. State policies aimed at raising requirements for time of instruction or number of courses have recently been viewed as insufficient to provide strong incentives for improving instruction or for determining the effectiveness of curriculum.

Even though content and performance standards are currently the favored approach to education reform, it is still important to monitor and report on the effects of major policy initiatives, such as raising course requirements, because such initiatives continue to be used widely as a strategy for encouraging higher-level content for more students.

In the 1980s, over 40 states raised the number of credits in science and mathematics required for graduation (Blank & Espenshade, 1988; Blank & Dalkilic, 1992). A survey of states in 1996 showed the following state totals for required credits in mathematics and science (CCSSO/State Education Assessment Center, 1996):

- 19 states require three credits of mathematics and one requires four credits;
- 11 states require three credits of science and one requires four credits;
- 18 states require two mathematics credits, and 26 states require two science credits; and
- six states leave graduation requirements to local districts. (See Appendix A for course credit requirements by state.)

Graduation requirements have gone up in almost all states. As of 1996, 43 states require at least two years of math and science. In 1980, only nine states had this requirement. There has been recent change as well—in 1992, 13 states required 2.5 or more credits of math, as compared to 20 in 1996; and in 1992 six states required 2.5 credits in science, as compared to 12 in 1996.

National trends on course taking, reported from national sample surveys of high school transcripts, indicate that enrollments in science and mathematics have risen significantly from 1982 to 1996 in the period when many of the requirements were raised. For example:

- In 1982, 37 percent of high school graduates took algebra 2; the rate increased to 62 percent of graduates in 1996 (NCES, 1997b).
- In 1982, 32 percent of graduates took chemistry while 55 percent of graduates took chemistry in 1996 (NCES, 1997b).

It does appear that higher science and math course enrollments is related to increased course credit requirements since 1991 (Blank et al., 1991, 1993, 1995). We have found that the states with the highest requirements have had slightly higher overall course enrollments in science and mathematics. However, because rates have gone up in almost all states, it is hard to determine specific effects of different policies on course taking. Porter's recent study of effects of state requirements at the local level did show that students were taking more mathematics and science courses in high school, and key courses such as algebra, biology, and chemistry did not have their curriculum content reduced as a result (Porter, et al., 1994).

Mathematics Trends by State Policies

- **All states reporting on trends since 1990 show an increase in the proportion of high school students taking higher level mathematics.**

- **Nationally, 43 percent of high school students took higher level math courses in 1996, an increase of nine points from 1990; and, 92 percent of high school students took a math course during the 1995–96 school year.**

CCSSO can now track the amount of change in course enrollments in relation to an individual state's requirements. Table 13 shows change from 1990 to 1996 in the percent of high school students taking higher-level mathematics, i.e., geometry (level 2) through calculus (level 5), according to a state's graduation requirements. The states with Statewide Systemic Initiatives (SSI) supported by NSF are identified.

Among the 14 states that had higher math requirements (three to four credits) in 1996, 10 of the 14 raised enrollments in higher-level math courses by six or more percentage points. Arkansas, DC, Kentucky, and Tennessee showed the greatest increases of over 10 points.

Among the 16 states requiring two credits in 1996, 10 states increased the percentage of students in higher-level math six or more points over six years. The percentage enrolled in higher-level math in 1996 varied from 34 percent (California and Delaware) to 48 percent (Montana).

In the third column of Table 13, we show the proportion of students in each state taking mathematics at any level in 1996. The national total is 92 percent of high school students, an increase of eight points from 83 percent in 1990. The high-requirement states vary in total enrollment from 79 percent in Alabama to 97 percent in Connecticut and 99 percent in Pennsylvania. In two-credit states, the total percent of students taking mathematics varies from 77 percent in Oregon to 99 percent in four states.

Science Trends by State Policies

- **Twenty-seven of 30 states reporting on trends in science enrollments since 1990 show an increase in the proportion of high school students taking higher level science.**

- **Nationally, 27 percent of high school students took higher level science courses in 1996, an increase of six points from 1990; and, 82 percent of high school students took a science course during the 1995–96 school year.**

Table 14 shows change from 1990 to 1996 in the percent of high school students taking higher-level science, i.e., chemistry, physics, or advanced/second-year courses, from 1990 to 1996, according to a state's graduation requirements.

In the eight states that had higher science requirements (three to four credits) in 1996, all raised enrollments in higher-level science courses by three or more percentage points. Arkansas, Delaware, DC, and Pennsylvania all increased higher-level science by 10 points.

Among the 20 states requiring two credits in 1996, 15 states increased the percentage of students in higher-level science by three or more points over six years. The percentage enrolled in higher-level science in 1996 varied from 17 percent (Idaho) to 40 percent (Mississippi).

In the third column of Table 14, we show the proportion of students in each state taking science at any level in 1996. The national total is 82 percent of high school students, an increase of 10 points since 1990. The range for high-requirement states is 67 percent in Hawaii to 99 percent in Arkansas, and the range for two-credit states is from 65 percent in California to 99 percent in West Virginia and Wisconsin.

The group of seven states that rely on local board policies on graduation requirements have enroll-

Table 13: Change in Higher-Level Mathematics Enrollments and State Graduation Requirements, 1990 to 1996

STATE *By Requirements*	% Students Taking Math at Level 2, 3, 4, or 5, 1996	Change: 1990 to 1996 % Taking Math, Level 2, 3, 4, or 5	% Students Taking Math (any course), 1996
	PERCENT OF GRADES 9–12 STUDENTS		
3 to 4 Credits (as of 1996)			
Alabama	32	+4	79
Arkansas (SSI '93)	43	+12	97
Connecticut (SSI '91)	47	+9	93
Delaware (SSI '91)	37	+9	91
Dist. of Columbia	48	+18	79
Hawaii	27	+6	90
Kentucky (SSI '92)	47	+12	96
Louisiana (SSI '91)	44	+1	87
Mississippi	46	+8	96
New Mexico (SSI '92)	35	+5	86
Pennsylvania	52	+6	99
Puerto Rico (SSI '92)	20	+1	82
Tennessee	39	+11	89
Texas (SSI '92)	44	+9	91
2 Credits (as of 1996)			
California (SSI '92)	34	+5	80
Idaho	41	+3	79
Illinois	50	+17	86
Indiana	42	+9	83
Missouri	46	+10	91
Montana (SSI '91)	42	+1	87
New York (SSI '93)	40	+6	91
North Carolina (SSI '91)	59	+22	99
North Dakota	53	+9	89
Ohio (SSI '91)	45	+9	89
Oklahoma	41	+7	88
Oregon	37	+5	77
South Dakota (SSI '91)	50	—	87
Utah	59	—	99
West Virginia	52	+22	99
Wisconsin	55	+8	99
1 Credit or Local Board Policies			
Iowa	48	+5	94
Massachusetts (SSI '92)	50	—	92
Minnesota	45	+4	74
Nebraska (SSI '91)	56	+20	99
NATION	**43**	**+9**	**92**

Example: 43% of Arkansas' 9–12 students took higher level math courses in 1996, while in 1990 only 31% took these courses.

Notes: Math Level 2–5 = Geometry, Algebra 2, Trigonometry, Pre-Calculus, or Calculus.
Delaware, Oregon, Puerto Rico, Wisconsin — change from 1992 to 1996. Illinois, Minnesota, Texas: 1994–95 data.
SSI = State with Statewide Systemic Initiative under NSF grant, five years starting 1991, '92, or '93. Other SSI = Florida, Georgia, Maine, Michigan, Vermont, Virginia, New Jersey, South Carolina.

Source: State Departments of Education, Data on Public Schools, 1995–96.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

ments as high as some states with high state requirements. Data on policies by district from the 1994 SASS (NCES, 1996b) show that local district policies often exceed state requirements. States such as Massachusetts, Minnesota, and Nebraska may have local requirements that lead to high rates of science and mathematics course taking.

This brief summary of CCSSO's analysis of course enrollments by state policies could be elaborated further. States may want to analyze enrollments by local requirements, or, enrollments could be analyzed by other policy differences within states, such as integrated science or mathematics curriculum versus a traditional sequence of courses.

Table 14: Change in Higher-Level Science Enrollments by State Graduation Requirements, 1990 to 1996

STATE *By Requirements*	% Students Taking Chemistry, Physics, or Advanced Science, 1996	Change: 1990 to 1996 % Taking Chemistry/Physics/Adv.	% Students Taking Science (any course), 1996
	PERCENT OF GRADES 9–12 STUDENTS		
3 to 4 Credits (as of 1996)			
Alabama	22	+4	76
Arkansas (SSI '93)	28	+17	99
Delaware (SSI '91)	29	+11	90
Dist. of Columbia	26	+10	79
Hawaii	21	+1	67
Louisiana (SSI '91)	21	+3	86
Pennsylvania	37	+10	91
Tennessee	19	+3	78
2 Credits (as of 1996)			
California (SSI '92)	19	+4	65
Connecticut (SSI '91)	33	+3	87
Idaho	17	0	75
Indiana	29	+5	77
Kentucky (SSI '92)	32	+9	86
Maine (SSI '92)	28	0	65
Mississippi	40	+5	84
Missouri	30	+3	87
Montana (SSI '91)	27	+3	83
New Mexico (SSI '92)	18	+4	70
New York (SSI '93)	28	+4	91
North Carolina (SSI '91)	30	+14	98
North Dakota	34	+9	89
Oklahoma	25	+12	81
Oregon	20	+1	71
South Dakota (SSI '91)	29	—	82
Texas (SSI '92)	23	+6	75
Utah	32	—	95
West Virginia	33	+12	99
Wisconsin	38	+8	99
1 Credit or Local Board Policies			
Illinois	34	+15	79
Iowa	27	+4	88
Massachusetts (SSI '92)	34	—	93
Minnesota	28	+5	68
Nebraska (SSI '91)	31	+15	99
Ohio (SSI '91)	25	+5	79
Puerto Rico (SSI '92)	19	-3	69
NATION	**27**	**+6**	**82**

Notes: Delaware, Maine, Oregon, Puerto Rico, Wisconsin—change from 1992 to 1996.

Illinois, Minnesota, Texas: 1994–95 data.

SSI = State with Statewide Systemic Initiative under NSF grant, five years starting 1991, '92, or '93. Other SSI = Florida, Georgia, Michigan, Vermont, Virginia, New Jersey, South Carolina.

Source: State Departments of Education, Data on Public Schools, 1995-96.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Middle Grades Mathematics and Science Course Enrollments

- ⇨ ***First-year algebra*** **courses were taken by over 20 percent of grade 8 students in nine states; and nationally, 15 percent of grade 8 students took algebra 1 in 1996.**

- ⇨ ***General science*** **is the science course taken by almost 40 percent of grade 7–8 students, 20 percent take *life science*, and 15 percent take *earth science*.**

The mathematics and science curricula for middle school students are highly varied both between states and within states. In mathematics, many states and districts are moving towards grade 8 curricula with greater emphasis on algebra. Table 15 shows that in 1996, 15 percent were taking *algebra* in grade 8, compared to 13 percent in 1990. The percent taking algebra in grade 8 varied from 6 percent in Louisiana to 32 percent in Massachusetts and 45 percent in Utah. *Pre-algebra* courses were taken by 17 percent of students in 1996. Half of the states reporting grade 7–8 data had less than half their students taking "regular math" courses in grade 8.

The course titles provide only a rough estimation of the content students are receiving. Content analyses show wide variation in the content in courses of "algebra," "pre-algebra," and "regular grade 8 math," but these categories do provide useful distinctions in the general level of math content that is taught (McKnight, et al.,1987).

The curriculum in grades 7 and 8 science is highly varied across states. *Life science* is taught to over a third of students in these grades in 14 states. In 11 states, over a third of students take a course called general science courses. Nine states have more than 15 percent of grade 7–8 students enrolled in *integrated* or *coordinated science* courses. In 10 states, over one-fourth of students take *earth science* in grades 7–8.

Table 15: Middle Grades Mathematics and Science Course Enrollments, 1996

	MATHEMATICS GRADE 8: % ENROLLED		
	Regular Math	Enriched/ Pre-Algebra	Algebra Grade 8
Alabama	54	5	14
Arkansas	59	0	8
California	43	28	20
Connecticut	44	27	25
Delaware	43	18	28
Dist. of Columbia	—	50	26
Hawaii	86	2	0
Idaho	44	29	18
Indiana	81	9	8
Kentucky	74	19	14
Louisiana	27	40	6
Maine	100	—	—
Massachusetts	44	21	32
Minnesota	28	—	8
Mississippi	56	41	11
Missouri	49	—	18
Montana	74	6	17
Nebraska	25	17	10
New Mexico	56	24	13
New York	76	0.2	20
North Carolina	—	—	24
North Dakota	53	30	13
Ohio	45	15	19
Oklahoma	42	36	9
Oregon	49	19	22
Pennsylvania	43	—	—
Puerto Rico	95	—	0
South Dakota	77	3	11
Tennessee	87	—	12
Utah	16	47	45
West Virginia	50	24	23
Wisconsin	71	8	21
NATION	**52**	**17**	**15**

	SCIENCE GRADE 7–8: % ENROLLED					
	Highest 3 Courses: Earth, Life, Physical, General, or Integrated Science					
Alabama	Gen.	54	Earth	31	Life	9
Arkansas	Life	38	Earth	38	Gen.	14
California	Gen.	55	Life	6	Phy.	6
Connecticut	Gen.	31	Life	23	Integ.	19
Delaware	Life	36	Earth	31	Gen.	24
District of Columbia	Life	41	Phy.	37		
Hawaii	Life	56	Phy.	38	Integ.	17
Idaho	Life	38	Phy.	23	Earth	16
Indiana	Gen.	95				
Kentucky	Integ.	52	Life	24	Earth	23
Louisiana	Life	23	Earth	21	Gen.	10
Massachusetts	Life	27	Integ.	20	Phy.	18
Minnesota	Life	25	Earth	21	Phy.	9
Mississippi	Gen.	70	Integ.	26		
Missouri	Gen.	38	Life	30	Earth	24
Montana	Life	45	Phy.	39	Earth	8
Nebraska	Life	13	Gen.	12	Phy.	12
New Mexico	Life	31	Earth	24	Gen.	21
New York	Life	37	Phy.	25	Gen.	13
North Carolina	Integ.	49				
North Dakota	Earth	50	Life	49		
Ohio	Gen.	48	Earth	12	Life	10
Oklahoma	Integ.	66	Earth	18	Gen.	7
Oregon	Life	24	Integ.	22	Earth	19
Pennsylvania	Gen.	29	Phy.	27	Life	22
Puerto Rico	Gen.	97				
South Dakota	Gen.	89				
Tennessee	Gen.	100				
Utah	Life	48	Earth	26	Integ.	23
West Virginia	Integ.	95				
Wisconsin	Gen.	39	Life	22	Earth	18
NATION	**Gen.**	**38**	**Life**	**20**	**Earth**	**15**

Notes: — Data not available.

Minnesota, Texas: 1994–95 data; In several states, e.g., Minnesota, Nebraska, North Carolina data from self-contained classrooms are not included in the totals.

Source: State Departments of Education, Data on Public Schools, 1995–96; NCES, CCD Fall Membership 1994.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Course Enrollments by Race/Ethnicity and Gender

POLICY ISSUES

- Are minority students increasing their participation in higher-level science and mathematics?
- Is the gender gap closing in higher-level science and mathematics?

Reforms in science and math education aim to increase opportunities among female and male students, and among minority and white students. States are trying to improve the knowledge and skills of all students in mathematics and science, and to raise student confidence by helping them reach challenging levels of course work. The goal of efforts toward equity is to prepare students for further study or to apply knowledge in careers. Course enrollments show patterns of progress in science and mathematics for females, minorities, and students from lower SES families. This progress is also important because we know that opportunities represented by course-taking levels are strong predictors of student learning in mathematics and science.

Course Enrollments by Race/Ethnicity

⇨ **Eleven states reported math and science enrollments by student race/ethnic groups, and all states show significant differences in rates of course taking by group.**

State enrollments by race/ethnicity for two course levels are reported in Table 16. CCSSO requested data by race/ethnicity from states for the first time in 1993–94, and eight reported. Now, 11 states have education data systems based on student-level records that allow states to aggregate and report enrollments by race/ethnicity.

The state percentages by race/ethnicity for students taking chemistry and algebra 2/integrated math 3 in 1996 can be compared with the percent of each group in the K–12 enrollment shown at the bottom of the page. Our analysis focuses on the major minority groups in each state because some groups in these states are very small. No state has achieved enrollments for black and Hispanic students comparable to whites.

- Black students' chemistry and algebra 2 enrollments in Delaware are more than 20 percentage points below the enrollment of white students. Connecticut's black students are more than 30 points below the enrollment of white students in these two courses.

- In Texas, Hispanic students' chemistry enrollment is 25 points below that for whites, and the algebra 2 enrollment is 30 points below the rate for whites. Hispanics in Massachusetts (9 percent of students) are 35 points below the enrollments of whites in chemistry and algebra 2.

- Black students in Ohio are only 14 points below the white enrollment in chemistry. Black students in North Carolina are about 20 points behind whites in chemistry and algebra 2.

National high school transcripts studies conducted by NCES are useful for analyzing long term national trends in math and science course-taking by student race/ethnicity and by student gender (NCES, 1997b) The national averages below show that minority students are making some progress in participation in higher-level mathematics and science courses. We have selected algebra 2 and chemistry to trace minority students' progress as compared to that of white students.

- The enrollment of black students taking algebra 2 increased significantly over the 1982 to 1994 period—from 26 percent to 44 percent of graduates. At the same time, however, the white-black gap in participation widened by four percentage points over 12 years (whites: 44% to 62%). Hispanic and American Indian students made the largest increases in algebra 2 enrollments—with both groups' enrollments doubling over 12 years. Asian American students continue to enroll in Algebra 2 at a higher rate than any other group—67 percent in 1994.

Table 16: Race/Ethnic Differences in Students Taking Chemistry and Algebra 2/Integrated Math 3, 1996

PERCENT OF HIGH SCHOOL STUDENTS TAKING CHEMISTRY BY GRADUATION

STATE	All Students	White	Black	Hispanic	Asian	Am. Ind.
Arkansas	65	70	49	65	65	49
Connecticut	63	70	40	32	95	95
Delaware	64	72	50	32	64	96
Dist. of Columbia	78	78	76	78	99	0
Hawaii	51	44	51	13	55	15
Idaho	41	43	41	18	41	21
Massachusetts	67	72	45	37	89	34
North Carolina	62	68	46	62	99	62
Ohio	58	60	46	58	99	58
Texas	55	65	46	39	99	55
Utah	47	49	9	19	47	24

PERCENT OF HIGH SCHOOL STUDENTS TAKING ALGEBRA 2/INTEGRATED MATH 3 BY GRADUATION

STATE	All Students	White	Black	Hispanic	Asian	Am. Ind.
Arkansas	67	71	56	67	67	50
Connecticut	65	71	37	41	98	65
Delaware	47	56	30	24	47	71
Dist. of Columbia	69	99	67	57	99	0
Hawaii	37	30	19	9	41	7
Idaho	61	63	99	35	61	31
Massachusetts	70	74	54	39	93	35
North Carolina	70	76	54	70	99	70
Texas	72	82	72	53	99	72
Utah	78	81	16	31	39	39

Note: Texas: 1994–95 data.

Source: State Departments of Education, Data on Public Schools, 1995–96 school year.

Race/Ethnicity of K–12 Students

	% White	% Black	% Hispanic	% Asian	% Am. Ind.
Arkansas	74	24	2	0.7	0.4
Connecticut	72	13	12	2	0.2
Delaware	65	29	4	2	0.2
Dist. of Columbia	4	88	7	1	*
Hawaii	23	3	5	69	0.4
Idaho	–	–	–	–	–
Massachusetts	79	8	9	4	0.2
North Carolina	65	31	2	1	2
Ohio	82	15	1	1	0.1
Texas	46	14	37	2	0.3
Utah	90	0.7	5	2	1

– Data not available.

* Less than 0.1 percent.

Source: NCES, Common Core Data, 1995–96.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

- In science, chemistry enrollments increased significantly from 1982 to 1994 for all groups. Black and Hispanic enrollments in chemistry more than doubled over 12 years—23 to 54 percent, 17 to 47 percent; white enrollments increased 24 percentage points, and Asian American enrollments increased by 17 points.

Race/Ethnic Differences in Students Taking Algebra 2 and Chemistry, 1982 to 1994

Percent Taking Algebra 2

Student Race/Ethnicity	1982	1994
White	41	62
Black	26	44
Hispanic	23	51
Asian	55	67
American Indian	20	39

Percent Taking Chemistry

Student Race/Ethnicity	1982	1994
White	35	59
Black	23	44
Hispanic	17	47
Asian	52	69
American Indian	34	41

Source: NCES, Conditions of Education, 1997b.

Course Enrollments by Gender

⇨ **Female students have greater enrollments in three years of high school math and science in all 18 states reporting by gender in 1996.**

⇨ **In 12 of 18 states, female enrollments have increased from 2 to 6 percentage points in trigonometry/pre-calculus since 1990, and increased 3 to 21 percent in the percent female taking physics.**

In analyzing course taking trends by student gender since 1990, we focus on the higher levels of math and science. In 1996, a total of 18 states reported course taking in math and science by gender. Table 17 shows trends by state on the percent of females among students taking higher level math and science, i.e., algebra 2/integrated math 3, trigonometry/precalculus, chemistry and physics.

All 18 states had more females than males taking algebra 2/integrated math 3 in 1994, varying from 50 percent (Utah) to 59 percent female (DC). In fourth year math (trigonometry/precalculus courses), 14 states had more females than males enrolled. The percent female taking higher-level mathematics increased since 1990 in 12 of 18 states reporting trend data. For example, in Alabama and Wisconsin, the percent female enrolled in level 4 math went up six percentage points in six years.

In science, all 18 states had more females taking chemistry than males, as of 1996, varying from 50 percent in Idaho to 56 percent female in Hawaii and North Carolina. Eighteen states (of 19) have more males than females taking physics. From 1990 to 1996, the percent female among students taking physics increased in 14 of 15 states with trend data, with increases from 2 to 21 percentage points. The proportion female of students taking physics varies from 42 percent in Idaho and Utah, 43 percent in Connecticut and Iowa, to 64 percent in Arkansas, 65 percent in District of Columbia.

National transcript data show that from 1982 to 1994 gender differences in higher-level math and science course enrollments have declined (NCES, 1997). The percentages for the two years show that in 1994 some courses had more female students enrolled than males, for example, algebra 2. In science, more females now take chemistry by graduation, while male students still have significantly higher enrollments in physics.

Higher-Level Mathematics and Science by Gender, 1982 to 1994

	Female %		Male %	
	1982	1994	1982	1994
Algebra 2	36	62	38	55
Trigonometry and Precalculus	17	36	19	33
Calculus	5	9	6	9
Chemistry	31	59	32	53
Physics	9	22	18	27

Source: NCES, Conditions of Education, 1997b.

Table 17: Gender Differences in Students Taking Higher-Level Mathematics and Science Courses, 1990 to 1996

STATE	% Female ALGEBRA 2/INTEGRATED MATH 3, 1996	% Change Female 1990 to '96	% Female TRIGONOMETRY/ PRE-CALCULUS, 1996	% Change Female 1990 to '96
Arkansas	54	0	55	+6
California	52	+1	52	+3
Connecticut	57	+1	52	+4
Delaware	53	—	49	—
Dist. of Columbia	59	0	62	0
Hawaii	57	+2	57	+5
Idaho	53	+6	50	+2
Illinois	52	+2	52	+4
Iowa	52	0	50	+3
Massachusetts	52	—	53	—
North Carolina	55	-1	54	0
Ohio	51	0	52	+2
Pennsylvania	52	+1	52	+2
Puerto Rico	56	—	51	-3
Texas	52	—	52	—
Utah	50	-1	48	+2
West Virginia	53	-2	54	+4
Wisconsin	53	+2	52	+6

STATE	% Female CHEMISTRY, 1996	% Change Female 1990 to '96	% Female PHYSICS, 1996	% Change Female 1990 to '96
Arkansas	54	+2	64	+21
California	53	+2	47	+5
Connecticut	53	+4	43	+7
Delaware	53	—	49	—
Dist. of Columbia	55	-2	65	+2
Hawaii	56	+1	52	+4
Idaho	50	-1	42	+11
Illinois	54	+3	49	+9
Iowa	53	+2	43	+3
Massachusetts	53	—	46	—
North Carolina	56	0	48	+3
Ohio	54	+2	44	+2
Pennsylvania	53	+1	47	+2
Puerto Rico	52	0	49	-5
Texas	53	—	46	—
Utah	51	+5	42	+9
West Virginia	54	0	48	+6
Wisconsin	55	+3	47	+7

Notes: — Data not available. Illinois, Texas: 1994–95 data.
North Carolina, Ohio, Puerto Rico, Utah: change from 1992 to 1996.

Source: State Departments of Education, Data on Public Schools.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Instructional Practices in Mathematics and Science

POLICY ISSUES

- To what extent are teaching practices consistent with national professional standards on teaching in mathematics and science?
- Are there major differences in instructional practices in mathematics and science across the states?
- Are differences in teaching practices related to higher student achievement in mathematics or science?

The NCTM curriculum standards and teaching standards (1989, 1991) and NRC science education standards (1995) recommend approaches to instruction that increase students' direct involvement in learning through doing mathematics and science and constructing ways of reasoning and solving problems. Many states have completed their own state standards and curriculum frameworks in mathematics and science that suggest teaching strategies or provide examples of classroom practices that are consistent with challenging content standards (Blank, et al., 1997). In the present report, we have selected data from the NAEP mathematics teacher survey to provide indicators of teaching practices useful for analyzing teaching in relation to NCTM standards.

Data on science teaching practices from the 1996 NAEP science assessment will be available in 1997, but were not released in time for this report. Several national-level indicators of science instructional practices from a recent national sample survey of teachers are referenced in this chapter (Weiss, 1994). A new survey approach to measuring science classroom practices and curriculum has been developed and field tested by the CCSSO State Collaborative on Assessment and Student Standards. States and districts can use the surveys to analyze science teaching in relation to their standards or assessments or to plan program improvements. The surveys are available from CCSSO (Martin, Blank, & Smithson, 1996).

Mathematics Instructional Practices, Grades 4 and 8

⇨ ***Discuss Solutions to Math Problems with Other Students.*** **In 12 states, over 50 percent of students in grade 4 discuss solutions to math problems with other students in class once per week or more.**

⇨ **At grade 8, 36 percent of students report they discuss math problems in class almost every day, and 65 percent discuss math problems in class at least once per week.**

This instructional practice is very prevalent across the nation. Often these students may be working with other students in small groups. This indicator addresses the problem solving and reasoning theme of the NCTM standards for mathematics education. Nationally, 48 percent of grade 4 students report discussing problems with other students at least weekly.

⇨ ***Use of Calculators, grade 4 and grade*** **8. In 1992, only 18 percent of grade 4 students across the United States reported using calculators in math class once per week or more, according to teacher reports. By 1996, the rate increased to 34 percent of students using calculators at least weekly.**

Eight states had over 40 percent of grade 4 students using calculators weekly or more, according to their teachers. By comparison, 49 percent of grade 8 students report they use calculators in math class almost every day, and 76 percent use them at least once per week in class.

⇨ ***Write about solving math problems, grade*** **8. One-third of students in grade 8, nationally, write about how to solve math problems in class once per week or more.**

Table 18 shows data by state on four instructional practices in mathematics in grade 4 classrooms: (a) Students discuss math problems in class with other students, (b) Students write a few sentences about how to solve math problems, (c) Use of calculators in math instruction, and (d) Homework assigned per day in math. The first two items are from student surveys, the

Table 18: Instructional Practices in Mathematics, Grade 4, 1996 NAEP

STATE	Students Discuss Math Problems % Once a Week or More	Write About Math Problems % Once a Week or More	Calculator Use % At Least Once a Week 1996	Calculator Use % At Least Once a Week 1992	Homework Assigned % 30 Minutes or More
Alabama	47	44	17	22	62
Alaska ▽	49	43	33	—	—
Arizona	49	46	22	15	32
Arkansas ▽	39	37	25	8	37
California	55	53	41	34	50
Colorado	50	48	34	31	36
Connecticut	54	55	36	29	44
Delaware	51	48	34	24	42
Dist. of Columbia	60	55	48	59	83
DDESS	48	42	43	—	—
DoDDS	66	61	73	—	—
Florida	48	46	32	21	57
Georgia	51	49	30	14	53
Guam	50	52	16	10	71
Hawaii	50	57	23	35	76
Indiana	47	41	24	12	33
Iowa ▽	46	39	26	18	18
Kentucky	53	54	52	47	41
Louisiana	48	45	21	18	54
Maine	49	57	51	23	34
Maryland	54	58	48	39	58
Massachusetts	56	52	37	18	47
Michigan ▽	48	48	56	38	32
Minnesota	48	46	52	28	24
Mississippi	49	50	21	16	55
Missouri	43	37	12	14	44
Montana ▽	43	42	38	—	—
Nebraska	45	40	37	22	30
Nevada ▽	46	51	32	—	—
New Jersey ▽	54	49	45	26	56
New Mexico	44	44	30	9	46
New York ▽	51	49	22	14	59
North Carolina	51	53	62	21	54
North Dakota	35	32	34	14	42
Oregon	46	46	40	—	—
Pennsylvania ▽	52	44	30	18	46
Rhode Island	50	49	40	18	45
South Carolina ▽	47	44	24	15	52
Tennessee	45	40	18	7	59
Texas	48	45	20	24	42
Utah	46	45	43	21	27
Vermont ▽	53	68	50	—	—
Virginia	45	42	30	14	49
Washington	46	40	31	—	—
West Virginia	46	45	50	24	28
Wisconsin	44	40	38	34	33
Wyoming	45	40	28	24	19
NATION	48	49	34	18	41

Notes: — Data not available.

▽ Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.

Source: NCES, Data Compendium for the NAEP 1996 Mathematics Assessment (see for standard errors).

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

next two from teacher surveys. The percentages represent the percent of students in each state affected by the practice—for example, teachers of 62 percent of Alabama's grade 4 students report they assign 30 minutes or more homework each day.

Table 19 reports the same four instructional practices for grade 8 math classes. The only difference in the items is that calculator use is reported by students in grade 8.

Applying mathematics to real-life needs and problems is a major emphasis of NCTM standards. Many states have recommended in their standards that instruction should develop students' abilities to communicate mathematically, such as by writing about how to solve a math problem. Three states have over 50 percent of grade 8 students writing about math problems weekly.

The fairly high frequency of students reporting they discuss solutions to math problems with other students may be somewhat surprising, given the common perception of U.S. math instruction as teacher-centered or individuals working on their own math assignments in class. One-third of grade 8 math classes involve some student interaction and cooperation almost daily, and half of grade 4 classes have students discussing their work at least weekly. These findings may indicate there is change taking place in methods of math instruction in our schools.

Writing about solving mathematics problems is used more often in grade 4 math classes than in grade 8, according to NAEP surveys with students. At grade 4, 49 percent of students report they write about solving math problems once a week or more, while at grade 8 only 35 percent report writing about math as often as once per week. Writing about math in grade 8 classes varied from 23 percent in Indiana, Utah, and West Virginia to 58 percent in Kentucky and 50 percent in California.

Calculator use in math instruction has risen significantly since 1992. Now, half of grade 8 students are using calculators almost daily, and 10 states have over 60 percent of students using calculators this often. At grade 4, about one-third of math classes use calculators once or twice a week. No state has over half their classes using calculators weekly, but all states have over one-fifth of classes using calculators once or twice per week.

Elementary Science Instructional Practices

A national sample of elementary, middle, and high school science and mathematics teachers were surveyed in fall 1993 about their instructional practices, preparation, classroom resources, and school conditions (Weiss, 1994). The survey results are an excellent resource on a broad range of national indicators.

Based on teacher reports of percentage of time spent on different class activities per week, we can summarize the predominant instructional practices in elementary science as follows (grades 1-4):

Figure 6: Science Instructional Practices	% of Class Time
Lecture or whole-class discussion	36
Hands-on activities or laboratory work	26
Students reading or doing work sheets	21
Small group work, non-lab	10
Non-instruction daily routines, interruptions	8

By contrast, the percent of time spent on instructional activities reported by high school science teachers was: 42 percent of time on lecture or whole-class discussion and only 21 percent on hands-on activities or laboratory work.

With regard to some specific science activities, 28 percent of elementary science teachers (grades 1–4) say students are never assigned a science project that takes more than a week, as compared to 22 percent of teachers in grades 5–8 and 43 percent of high school teachers.

Computers are never used by students in 38 percent of elementary science classes, 44 percent of grade 5–8 classes, and 54 percent of high school classes (Weiss, 1994). Students never take field trips in 23 percent of elementary classes (thus, 77 percent of classes do take one or more field trips), as compared to 35 percent of grade 5–8 classes and 62 percent of high school science classes which take no field trips.

Table 19: Instructional Practices in Mathematics, Grade 8, 1996 NAEP

STATE	Students Discuss Math Problems % Almost Every Day	Write About Math Problems % Once a Week/More	Calculator Use % Almost Every Day 1996	Calculator Use % At Least Once a Week 1996	Calculator Use % At Least Once a Week 1992	Homework Assigned % 30 Minutes or More
Alabama	36	25	30	57	49	73
Alaska ▽	37	29	58	83	—	—
Arizona	39	34	52	76	49	64
Arkansas ▽	32	22	36	64	42	66
California	39	50	48	76	56	69
Colorado	40	33	52	78	70	73
Connecticut	35	34	44	73	53	74
Delaware	34	36	51	78	53	69
Dist. of Columbia	45	42	20	48	56	79
DDESS	38	36	26	64	—	—
DoDDS	43	50	63	88	—	—
Florida	33	26	42	70	46	66
Georgia	39	30	47	74	47	64
Guam	42	34	36	63	30	64
Hawaii	36	37	26	57	46	78
Indiana	34	23	36	65	41	66
Iowa ▽	31	28	60	85	67	70
Kentucky	29	58	52	84	66	64
Louisiana	35	26	26	52	39	61
Maine	37	34	53	82	73	72
Maryland ▽	34	36	37	66	49	70
Massachusetts	35	32	47	74	35	84
Michigan ▽	42	39	67	87	68	71
Minnesota	33	27	65	86	75	70
Mississippi	38	34	33	60	31	66
Missouri	32	25	60	82	75	70
Montana ▽	39	35	60	85	—	—
Nebraska	38	25	60	83	69	65
New Mexico	37	26	38	66	46	64
New York ▽	32	32	36	64	29	73
North Carolina	40	37	47	76	44	67
North Dakota	37	25	71	86	72	78
Oregon	39	33	59	83	—	—
Rhode Island	29	25	40	68	47	80
South Carolina ▽	36	36	35	64	46	60
Tennessee	33	25	27	57	42	69
Texas	37	29	35	64	62	66
Utah	37	23	63	84	67	68
Vermont ▽	35	45	52	81	—	—
Virginia	34	26	37	65	43	65
Washington	40	25	51	76	—	—
West Virginia	32	23	35	63	43	44
Wisconsin ▽	30	30	62	86	71	65
Wyoming	35	23	55	79	71	56
NATION	**36**	**35**	**49**	**76**	**53**	**67**

Notes: — Data not available.

▽ Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.

Source: NCES, Data Compendium for the NAEP 1996 Mathematics Assessment (see for standard errors).

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

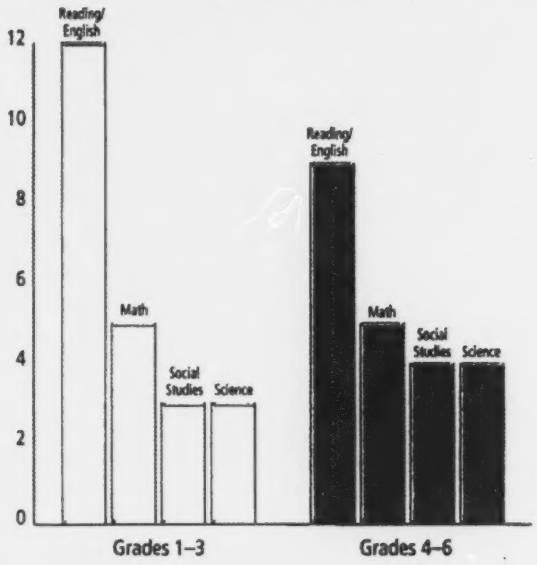
Elementary Class Time on Math and Science

POLICY ISSUES:

- What is the amount of class time students are taught math and science in elementary grades?
- Is the amount of time for math and science increasing or decreasing? What are the differences across states?

In the Schools and Staffing Survey (SASS) for 1994, elementary school teachers reported the amount of time spent per week on four academic subjects: reading, math, social studies, and science. The Survey included an average of 800 teachers per state, selected to provide a state-representative sample. Figure 7 shows the average class time by subject, nationally, reported by elementary teachers for grades 1–3 and 4–6.

Figure 7: Average Hours Per Week Spent on Core Academic Subjects as Reported by Elementary Teachers, 1994



Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Survey, 1994.

Time on grades 4–6 mathematics averaged 5.1 hours per week, second in time spent to reading/language (9.3 hours). Science averaged 3.5 hours per week, slightly less than 3.8 for social studies. The time for grades 1–3 math was slightly higher at 5.3 hours per week, and grades 1–3 science had about 30 minutes less than 4–6 at 2.9 hours per week.

- ***Science class time in grades 4–6.*** **Twelve states average over 3.8 hours per week, or 20 minutes more per week than the national average (3.5). Alabama, Louisiana, Missouri, New York, Tennessee, and Texas classes average over four hours of science per week. Over the school year, these states average 36 hours more science instruction than states at three hours of science per week.**
- ***Mathematics class time, grades 4–6.*** **Six states average over 5.4 hours per week, or 20 minutes more per week than the national average (5.1). Classrooms in these states (DC, New Hampshire, New Jersey, New York, Utah, and West Virginia) average 12 hours of mathematics more per year than the average classroom in the nation.**
- **Nationally, the average time on mathematics went up from 1991 to 1994 about 20 minutes per week (4.8 to 5.1). Science class time went up almost 30 minutes over that period (3.1 to 3.5).**

Class time on mathematics and science instruction is shown in Table 20. Class time on mathematics instruction in grades 4–6, as reported by teachers, varied from over 5.4 hours per week, or 65 minutes per day, in six states to less than 4.5 hours per week (Iowa, South Carolina) or 52 minutes per week. The amount of time is quite consistent across states. Time can add up—over a year, classes in states with 5.4 hours per week provide 194 hours of mathematics, while classes in the states at the low end provide 155 hours of mathematics—a difference of 39 hours, or seven weeks of classes.

Table 20: Elementary Class Time per Week on Math and Science, Grades 4–6, 1991 to 1994

	MATHEMATICS			SCIENCE		
	Avg. Hours/Week, Grades 4–6			Avg. Hours/Week, Grades 4–6		
STATE	1994	1991	(1994 Std. Error)	1994	1991	(1994 Std. Error)
Dist. of Columbia	6.5	—	0.6	3.9	—	0.6
New York	5.6	5.2	0.4	4.3	2.7	0.7
Utah	5.5	4.5	0.2	3.3	2.8	0.2
New Hampshire	5.4	5.1	0.3	3.1	3.7	0.3
New Jersey	5.4	4.3	0.4	3.8	2.9	0.4
West Virginia	5.4	4.7	0.3	3.7	3.2	0.3
Alabama	5.3	5.3	0.2	4.1	3.9	0.2
Connecticut	5.3	4.3	0.1	3.2	2.3	0.2
Nevada	5.3	5.2	0.3	2.9	4.0	0.1
North Carolina	5.3	4.5	0.4	3.9	3.2	0.3
Oklahoma	5.3	4.7	0.4	3.8	3.5	0.3
Pennsylvania	5.3	4.9	0.3	3.7	3.2	0.4
Rhode Island	5.3	5.2	0.2	2.8	2.7	0.2
California	5.2	5.4	0.1	3.2	2.6	0.3
Georgia	5.2	4.4	0.2	3.9	3.5	0.4
Maryland	5.2	4.6	0.2	2.5	3.4	0.2
Mississippi	5.2	3.8	0.5	3.8	3.8	0.5
Montana	5.2	4.8	0.1	3.6	3.7	0.1
Hawaii	5.1	4.5	0.2	2.6	2.5	0.2
Massachusetts	5.1	4.5	0.1	3.2	2.5	0.3
Minnesota	5.1	5.0	0.3	3.2	3.1	0.3
Ohio	5.1	5.2	0.3	3.4	3.0	0.3
Tennessee	5.1	5.4	0.2	4.3	3.5	0.7
Texas	5.1	4.1	0.2	4	3.8	0.3
NATION	**5.1**	**4.8**	**<.05**	**3.5**	**3.1**	**0.1**
Alaska	5	4.9	0.1	2.9	2.8	0.1
Arizona	5	4.9	0.1	2.8	2.7	0.2
Florida	5	4.8	0.2	3.1	3.1	0.2
Idaho	5	5.5	0.2	3.1	3.9	0.1
Indiana	5	4.5	0.3	3.7	3.4	0.4
Kansas	5	4.9	0.1	2.8	3.2	0.2
Missouri	5	4.7	0.2	4.3	3.7	0.9
Wyoming	5	4.8	0.2	3	3.7	0.2
Arkansas	4.9	4.6	0.3	3.8	3.7	0.3
Maine	4.9	4.7	0.3	3.3	3.4	0.2
Michigan	4.9	4.9	0.2	3.3	3.0	0.2
Nebraska	4.9	5.0	0.1	3.2	3.4	0.4
South Dakota	4.9	4.9	0.2	3.6	3.8	0.2
Vermont	4.9	4.8	0.2	3.6	3.9	0.2
Virginia	4.9	4.9	0.2	3.6	3.1	0.4
Kentucky	4.8	5.0	0.4	3.7	3.3	0.4
Louisiana	4.8	4.5	0.3	4.3	3.1	0.2
Washington	4.8	4.1	0.1	2.6	2.6	0.2
Colorado	4.7	4.7	0.2	3.7	2.8	0.4
New Mexico	4.7	4.5	0.2	3.1	4.1	0.2
North Dakota	4.7	5.2	0.1	3.8	4.3	0.1
Wisconsin	4.7	5.2	0.2	3.1	3.5	0.2
Illinois	4.6	5.4	0.1	3.7	3.2	0.5
Oregon	4.5	4.5	0.2	2.7	2.8	0.2
South Carolina	4.4	4.3	0.5	3.4	3.3	0.3
Iowa	4.3	4.6	0.3	3.6	2.4	0.4
Delaware	—	—	—	3.6	—	0.5

Notes: 3.0 hours per week = 108 hours/year (36 weeks), 5.0 hours/week = 180 hours/year.

— Respondents too few for a reliable state estimate.

Source: NCES, Schools and Staffing Survey, Public School Teachers, Washington, DC: U.S. Department of Education.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Science class time in grades 4–6, as reported by teachers, varied from over 3.8 hours per week, or 45 minutes per day in 12 states to less than 2.7 hours per week (Maryland, Oregon, Washington) or 32 minutes per week. The amount of time is more variable than in math. Over a year, classes in states with 3.8 hours per week provide 39 hours more science time than classes in states at 2.7 hours per week—or seven more weeks of science class.

Considering the consistent research findings on the positive relationship of instructional time to achievement, we would expect that students in the states with significantly more time spent on mathematics and on science would show higher scores on student assessments if other differences among states are taken into consideration.

- ◇ **Teachers Certified in Assigned Field in Mathematics and Science**
- ◇ **Teachers with a Major in Assigned Field**
- ◇ **Teachers Professional Development**
- ◇ **Teachers Race/Ethnicity, Gender, and Age**
- ◇ **New Teachers in Mathematics and Science**

National professional standards in mathematics and science, as well as the standards in many states, call for change in teaching and classroom practices to emphasize active learning by students, deep understanding of concepts, and developing skills in problem-solving and reasoning (NCTM, 1989, 1991; AAAS, 1993; NRC, 1995; Blank, et al., 1997). The standards for teaching in mathematics and science de-emphasize teacher lectures, memorizing facts and terminology, and curriculum aimed at briefly covering many topics. One implication of challenging content standards for all students is that teachers need in-depth knowledge and understanding of the discipline and skills in a variety of classroom practices that actively engage students in mathematics and science.

POLICY ISSUES

Indicators for mathematics and science education in the area of teacher preparation and teacher supply should be able to inform educators, policy makers, and the public about conditions and trends concerning current teachers and needs for improving the teaching force:

- ◦ What proportion of current teachers have knowledge and teaching skills in their field at the level outlined by professional standards?
- ◦ Do we have a sufficient number of teachers currently, and are new teachers coming into math and science that would allow us to improve the quality of teaching?
- ◦ What improvement in the knowledge and skills of teachers are needed? What efforts are currently being made to improve teachers' knowledge and skills?

The currently available state-by-state indicators regarding teachers and teaching provide some answers to these issues. From state education information systems, we can report state statistics from 1995–96 on: the proportion of teachers with state certification in their assigned teaching field; the number of teachers by race, gender, and age; and the number of new teachers entering math and science teaching. We can report statistics by state on the level of preparation of teachers in their assigned teaching field based on data by state from the Schools and Staffing Survey (SASS) and from the National Assessment on Educational Progress (NAEP). Finally, state indicators on the amount and types of professional development received by secondary teachers are available from SASS for the 1993–94 school year.

Teachers Certified in Assigned Field

State certification in the assigned teaching field indicates that teachers have a basic level of preparation in the subject they are teaching. Using teacher personnel files and teacher assignment data, states reported the number of teachers of high school mathematics and science who are certified. States reported on certification status by specific science fields, such as biology, and by percent of time assigned to the field (or, by main assignment vs. second or third assignment). The proportion of teachers who are certified in the subjects they are teaching is an important policy indicator for state and local educators because state certification is often used as a basic measure of teacher qualification and as an indicator of teacher supply and shortage. It is not, however, an adequate measure of quality of teacher preparation, particularly in cross-state comparisons, because of the differing state standards for certification. State certification requirements for secondary, middle grades, and elementary teachers are in Appendix A of this report and were initially reported

in *Key State Education Policies on K–12 Education* (CCSSO/SEAC, 1996; the report is available on the Internet, www.ccsso.org).

High School Teachers Certified in Field

⇨ **The certification statistics by state as of 1995–96 show that half the states have over 95 percent of high school science and math teachers certified in their assigned fields, including main and secondary assignments. One-fourth of the states have shortages of certified teachers in all fields of math and science.**

Mathematics: In Table 21, state data show that 16 states (of 31 reporting states) have over 95 percent of all high school math teachers certified in mathematics. At the same time, six states (California, Hawaii, Louisiana, North Carolina, Texas, Utah) have major teacher shortages with less than 90 percent of higher school math teachers certified in math. As a nation, the aggregated state data show that 88 percent of all high school mathematics teachers in 1996 were state-certified in mathematics, as compared to 91 percent in 1990. The 12 percent of high school math teachers not certified represents a total of 17,000 teachers across the nation. Of 143,000 teachers of mathematics in grades 9–12, 65 percent have their main assignment in mathematics (based on 1995–96 state data reported to CCSSO).

Biology: Fifteen states, or half the reporting states, have over 95 percent of biology teachers certified in biology or broad-field science. One state is below 80 percent certified in biology (Texas) and seven states are below 90 percent. Nationally, 86 percent of biology teachers are certified in their field, as compared to 92 percent in 1990. Currently, there are 58,000 teachers in the nation assigned to high school biology. Of all teachers assigned in biology, 62 percent have their main assignment in the field.

Chemistry: In this field, 14 states have over 95 percent of chemistry teachers certified. Three states (Hawaii, Idaho, Nebraska) have less then 80 percent of teachers certified in field, and four states have less then 90 percent certified in chemistry. Nationally, there are 25,000 teachers of chemistry, and 92 percent are certified in the field which shows no change from 1990. Among all teachers of chemistry, 57 percent have their main assignment in this field.

Physics: Of the reporting states, nine states have over 95 percent certified in physics. Thirteen states have less than 90 percent of physics teachers certified in the field, and four more states have less than 80 percent certified. In the nation, 87 percent of the 16,000 physics teachers are certified, which is slightly less than the 88 percent certified in 1990. Two-thirds of all teachers assigned to physics have their main assignment in another field (e.g., chemistry, physical science, earth science, mathematics, etc.)

Earth science: Fifteen states have over 90 percent of earth science teachers certified in this field or broad-field science. Nationally, only 69 percent of the 17,000 teachers of earth science are certified in this field; 13 states have less than 80 percent of earth science teachers certified as of 1996. Earth science is the main assignment of 51 percent of all teachers assigned to the subject.

High School Teachers **Not** Certified in Assigned Field

	Math	Biology	Chem.	Physics	Earth Science
1990	10%	8%	8%	12%	–
1994	12	10	8	14	19
1996	12	14	8	13	31

Note: – Data not reported

Source: State Departments of Education, 1990–96.

Table 21 summarizes the percentage of high school teachers by state that are assigned to mathematics, biology, chemistry, physics, and earth science and certified to teach in these fields. "Certification" in a field means the teacher holds a state's regular, standard, advanced, or probationary certificate in the assigned field/subject. In science, the teacher holds a "specific-field" certification (e.g., biology) or a "broad-field" certification (multiple fields of science. "Not certified" means the teacher holds an emergency or temporary certificate or holds a certification in a field other than the assigned field.

Table 21: Certification of Mathematics and Science Teachers, Grades 9–12, 1996

	% CERTIFIED IN ASSIGNED FIELD				
STATE	Mathematics	Biology	Chemistry	Physics	Earth Science
Alabama	96	96	92	85	59
Alaska	—	—	—	—	—
Arizona	—	—	—	—	—
Arkansas	94	94	93	88	92
California	80	82	82	84	66
Colorado	—	—	—	—	—
Connecticut	99	97	95	91	78
Delaware	93	93	93	86	82
Dist. of Columbia	100	100	100	100	—
Florida	—	—	—	—	—
Georgia	—	—	—	—	—
Hawaii	76	76	69	75	73
Idaho	98	99	78	77	94
Illinois	95	88	94	94	93
Indiana	97	96	96	86	74
Iowa	—	—	—	—	—
Kansas	—	—	—	—	—
Kentucky	98	97	97	85	46
Louisiana	88	83	83	68	48
Maine	—	—	—	—	—
Maryland	—	—	—	—	—
Massachusetts	91	92	96	96	89
Michigan	—	—	—	—	—
Minnesota	100	100	100	100	100
Mississippi	—	—	—	—	—
Missouri	95	94	94	85	72
Montana	98	99	99	97	96
Nebraska	90	90	77	69	66
Nevada	—	—	—	—	—
New Hampshire	—	—	—	—	—
New Jersey	—	—	—	—	—
New Mexico	95	94	98	97	97
New York	93	89	91	85	78
North Carolina	87	88	91	88	77
North Dakota	100	100	100	100	100
Ohio	96	89	93	92	72
Oklahoma	100	100	100	99	98
Oregon	—	—	—	—	—
Pennsylvania	91	96	95	95	95
Puerto Rico	90	99	99	94	92
Rhode Island	100	100	100	100	100
South Carolina	—	—	—	—	—
South Dakota	92	96	95	89	95
Tennessee	90	92	93	83	88
Texas	81	74	87	77	53
Utah	89	89	84	84	71
Vermont	—	—	—	—	—
Virginia	—	—	—	—	—
Washington	—	—	—	—	—
West Virginia	—	—	—	—	—
Wisconsin	100	100	100	100	100
Wyoming	—	—	—	—	—
NATION	**88**	**86**	**92**	**87**	**70**

Notes: — Data not available. Certified = Teachers assigned one or more period to subject who have state certification in subject. Science Certified = specific-field or broad-field certification. Delaware: Main assignment only; Minnesota: 1994–95 data; Pennsylvania: grades 7–12.

Source: State Departments of Education, Data on Public Schools, Fall 1995.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Middle Level Teachers Certified in Field

⇨ **Nationally, 65 percent of grade 7–8 mathematics teachers are certified in math, 17 percent are certified in elementary teaching, and 18 percent are not certified. In the nation, 63 percent of grade 7–8 science teachers are certified in science, 19 percent are certified in elementary teaching, and 18 percent are not certified.**

Many states find that indicators on middle school science and mathematics teachers are critical indicators for two reasons. First, middle grades classes are often where students develop strong interests and aspirations in science and mathematics, or, their interests shift to other subjects or their interest and achievement in science and math decline. Second, middle grades is often where states, districts, and schools find it is difficult to fill positions with well-qualified teachers in science and mathematics. In the state science-math indicators system, we ask states to report separately on the status of all grade 7 and 8 math and science teachers. We asked to receive data on the total number assigned to each subject, and then we asked states to differentiate between teachers assigned to grades 7–8 math and science that are certified in elementary education and those certified in math or science. The results in Table 22 show the following:

- *Grades 7–8 Mathematics:* The certification data on middle school math teachers shows that many states have a problem finding math-certified teachers. Only 12 of 28 states reporting data have more than 80 percent of grade 7–8 math teachers that are certified in math. The figures vary widely—from 19 percent in Hawaii and 28 percent in Kentucky, to all teachers certified in math in Minnesota and Rhode Island. In three states, over one-fourth of middle level math teachers are not certified—Hawaii, North Carolina, and Texas.

Elementary certification is the dominant pattern for math and science teachers in six states, with 50 percent or more teachers with elementary certification in: Connecticut, Illinois, Kentucky, Mississippi, Montana, and Oklahoma. In the nation, 65 percent of grade 7 and 8 math teachers are certified in math, 17 percent are certified in elementary teaching, and 18 percent are not certified. Nationally, there is a total of 92,000 math teachers in grades 7–8 and 59 percent have their main assignment in math.

- *Grades 7–8 Science:* The state data on certification status of middle school science teachers show that many states also have a problem finding certified teachers in science. Only nine of 28 states reporting data have more than 80 percent of grade 7–8 science teachers that are certified in science. The figures vary widely—from 23 percent in Kentucky to 44 percent in California, to all science teachers certified in Minnesota and Rhode Island. In six states, over one-fourth of middle level science teachers are not certified—i.e., in Hawaii, Louisiana, Nebraska, North Carolina, Tennessee, and Texas.

A majority of science teachers have elementary certification in four states: Illinois, Kentucky, Mississippi, New Mexico. In the nation, 63 percent of grade 7–8 science teachers are certified in science, 19 percent are certified in elementary teaching, and 18 percent are not certified. Of the 70,000 teachers of science in grades 7–8, 66 percent have their main assignment in science.

Broad-field Science Certification

Two-thirds of the states have a certification for "broad field" secondary science certification that covers teaching in biology, chemistry, physics, and other science subjects. Most states also have certification in the specific fields of biology, chemistry, physics, etc. See the Appendix for differences in state certification requirements.

Our analysis of state data by type of science certification revealed that almost one-third of all high school science teachers are certified through a broad field certification. Many schools in smaller, rural districts must hire teachers to teach two or three science subjects, and they tend to hire teachers who have received state certification through a broad-field, or "non-specialist," method of science certification.

Table 22: Certification of Mathematics and Science Teachers, Grades 7–8, 1996

STATE	MATHEMATICS			SCIENCE		
	% Certified Math	% Certified Elementary	% Not Certified	% Certified Science	% Certified Elementary	% Not Certified
Alabama	78	17	4	80	14	6
Alaska	—	—	—	—	—	—
Arizona	—	—	—	—	—	—
Arkansas	—	—	—	—	—	—
California	51	36	13	44	42	14
Colorado	—	—	—	—	—	—
Connecticut	48	50	2	53	45	2
Delaware	77	18	5	81	16	3
Dist. of Columbia	100	0	0	100	0	0
Florida	—	—	—	—	—	—
Georgia	—	—	—	—	—	—
Hawaii	19	47	34	29	42	28
Idaho	54	45	1	75	23	2
Illinois	0	97	3	0	95	5
Indiana	90	8	2	92	5	3
Iowa	—	—	—	—	—	—
Kansas	—	—	—	—	—	—
Kentucky	28	67	5	23	67	10
Louisiana	85	0	15	74	0	26
Maine	—	—	—	—	—	—
Maryland	—	—	—	—	—	—
Massachusetts	62	30	8	68	27	5
Michigan	—	—	—	—	—	—
Minnesota	100	0	0	100	0	0
Mississippi	39	55	0.3	45	54	1
Missouri	82	0	18	76	0	24
Montana	47	50	3	54	44	2
Nebraska	92	—	8	73	—	27
Nevada	—	—	—	—	—	—
New Hampshire	—	—	—	—	—	—
New Jersey	—	—	—	—	—	—
New Mexico	49	49	2	45	52	3
New York	91	0	9	85	0	15
North Carolina	65	4	31	60	4	36
North Dakota	59	41	0	69	31	0
Ohio	—	—	—	—	—	—
Oklahoma	49	51	0.2	60	39	0.2
Oregon	—	—	—	—	—	—
Pennsylvania	—	—	—	—	—	—
Puerto Rico	84	0	16	99	0	1
Rhode Island	100	0	0	100	0	0
South Carolina	—	—	—	—	—	—
South Dakota	97	0	3	93	0	7
Tennessee	96	0	4	93	0	7
Texas	63	0	37	60	0	40
Utah	80	0	17	70	0	27
Vermont	—	—	—	—	—	—
Virginia	—	—	—	—	—	—
Washington	—	—	—	—	—	—
West Virginia	—	—	—	—	—	—
Wisconsin	—	—	—	—	—	—
Wyoming	—	—	—	—	—	—
NATION	**65**	**16**	**18**	**63**	**19**	**18**

Notes: — Data not available.

Certified math (science) = Teachers assigned one or more period to subject who have state certification in secondary math (science) or middle level math (science). Certified Elementary = Certification in Elementary Education, General Secondary/Middle, or subject not assigned. Delaware: Main assignment only; Minnesota: 1994–95 data; Texas: % not certified includes elem./middle.

Source: State Departments of Education, Data on Public Schools, Fall 1995.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Teachers with a Major in Assigned Field

A second state-by-state indicator of the preparation of teachers in their assigned teaching field of science or mathematics is the percentage of teachers that hold a major in that field in an undergraduate or graduate degree. A major in the teaching field is a relatively consistent measure of the extent of knowledge of the subject by teachers. Research has shown a positive relationship between amount of course work preparation of teachers in science and mathematics and student learning in those fields (Shavelson, 1989; CCSSO, 1993; Mullis, 1993). A recent analysis of data from a National Longitudinal study showed that each additional mathematics course taken by mathematics teachers above the average for teachers translates into two to four percent higher student achievement (Monk, 1993).

Secondary Mathematics Teachers with Major

- ⇨ **Eight states have over 90 percent of secondary math teachers with a major or minor in math or math education, based on teacher survey data from 1994. At the same time, 12 states have less than 72 percent of math teachers with a major or minor. Thus, in these states over one-fourth of secondary teachers of mathematics do not have adequate preparation in that field.**

- ⇨ **Nationally, 80 percent of all secondary teachers of math (main or second assignment) have a major or minor in math; and, 72 percent of secondary teachers with their main assignment in math had a major in that field. The national figure of 20 percent without adequate math preparation represents a total of over 46,000 secondary teachers of math.**

The 1994 Schools and Staffing Survey (SASS) provides the most recent state-by-state statistics on college majors of teachers by their teaching assignments. The survey is conducted with a representative sample of elementary and secondary teachers in each state. Figure 8 shows a bar graph with states rank-ordered according to the percentage of secondary mathematics teachers (grades 7–12) that have a major in math or math education. States with over 90 percent of their secondary mathematics teachers with a major or minor in math are: Pennsylvania, Minnesota, Missouri, North Dakota, Iowa, Indiana, Montana, and Rhode Island.

States with less than 70 percent of math teachers that are well prepared in the field are: Tennessee, Louisiana, Idaho, Hawaii, Arizona, California, Oregon, Alaska, and Washington.

Table 23 reports states alphabetically according to secondary teachers with main assignment in math and science, and all teachers with one or more periods assigned in math and science. The percentage of teachers with their main assignment in math that have a major in math or math education varies from 46 percent in Idaho, and 50 percent in Alaska and California, to 98 percent in Pennsylvania and 94 percent in Minnesota. The data indicate that in some rural states and states with sharp increases in enrollments (e.g., California, Utah), it is more difficult to hire math teachers with a major in that field.

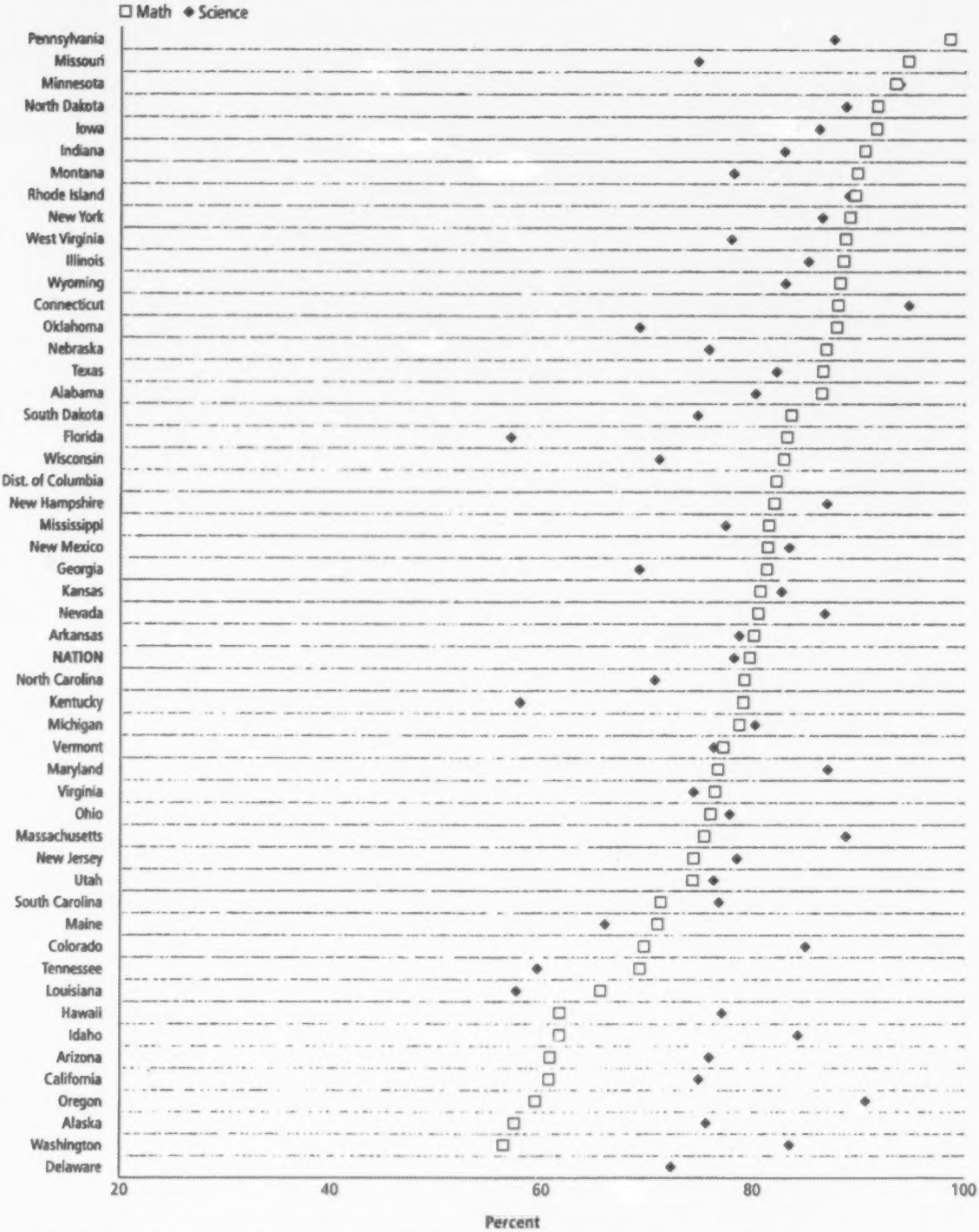
Secondary Science Teachers with Major

- ⇨ **Eleven states have over 85 percent of secondary teachers with a major or minor in science or science education, based on SASS teacher survey data from 1994. At the same time, seven states have less than 70 percent of science teachers that have a major or minor. Thus, in these states over one-fourth of secondary science teachers do not have adequate preparation in that field.**

- ⇨ **Nationally, 78 percent of all teachers with an assignment in science have a science major or minor. Among teachers with their main assignment in science, 74 percent have a major in science.**

Figure 8 also shows the percent of of secondary science teachers (grades 7–12) with a science major or minor. The survey asked teachers with one or more period assigned to any science subject if they had a major or minor in any field of science (e.g., biology, chemistry, geology) or in science education. States that have over 85 percent of secondary science teachers with a major

Figure 8: Percent of Mathematics and Science Teachers with Major or Minor in Field, Grades 7–12, 1994



Notes: Teachers = Public school teachers with main or second assignment in subject in grades 7–12 departmentalized instruction.
Major/minor = Undergraduate or graduate degree major or minor in math or math education (science or science education).

Source: NCES, Schools and Staffing Survey, 1993–94.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Table 23: Mathematics and Science Teachers with Major in Assigned Field, Grades 7–12, 1994

STATE	MAIN ASSIGNMENT		MAIN OR SECOND ASSIGNMENT	
	Math % with Major in Math	Science % with Major in Science	Math % with Major or Minor	Science % with Major or Minor
Alabama	89	73	87	80
Alaska	50	79	57	76
Arizona	61	73	61	76
Arkansas	70	66	80	79
California	50	62	61	75
Colorado	65	78	70	85
Connecticut	84	90	88	95
Delaware	—	82	—	72
Dist. of Columbia	82	—	82	—
Florida	76	52	83	57
Georgia	82	68	81	69
Hawaii	69	74	62	77
Idaho	46	77	62	84
Illinois	82	77	89	85
Indiana	81	78	91	83
Iowa	74	86	92	86
Kansas	63	78	81	83
Kentucky	79	55	79	58
Louisiana	63	57	66	58
Maine	68	67	71	66
Maryland	73	86	77	87
Massachusetts	76	89	75	89
Michigan	61	73	79	80
Minnesota	94	97	93	94
Mississippi	72	73	82	77
Missouri	89	70	95	75
Montana	77	76	90	78
Nebraska	83	79	87	76
Nevada	74	88	81	87
New Hampshire	76	91	82	87
New Jersey	69	82	74	79
New Mexico	69	71	81	83
New York	84	85	89	87
North Carolina	79	73	79	71
North Dakota	87	85	92	89
Ohio	64	75	76	78
Oklahoma	74	62	88	69
Oregon	61	93	59	91
Pennsylvania	98	85	99	88
Rhode Island	81	94	90	89
South Carolina	72	74	71	77
South Dakota	67	72	84	75
Tennessee	59	52	69	60
Texas	65	70	87	82
Utah	55	66	74	76
Vermont	75	81	77	76
Virginia	69	67	76	74
Washington	49	83	56	84
West Virginia	80	76	89	78
Wisconsin	76	68	83	71
Wyoming	78	80	88	83
NATION	**72**	**74**	**80**	**78**

Notes: — Data not available. Percent with major = Percent of assigned teachers with an undergraduate or graduate degree with a major in math (science field) or math education (science education). (See Appendix A for standard errors.) Public school teachers in departmentalized instruction with main or second assignment in subject in grade 7 through 12.

Source: NCES, Schools and Staffing Survey, 1993–94.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

71

or minor in a science field or science education are: Connecticut, Minnesota, Oregon, Rhode Island, Massachusetts, North Dakota, Pennsylvania, Maryland, New Hampshire, Nevada, New York, and Iowa.

In Table 23, we can compare the preparation of teachers with main assignment in science with the preparation of teachers with major or secondary assignment in science, which include teachers assigned to any science subject (earth science, biology, chemistry, etc.). In total, over three-fourths of all U.S. secondary science teachers have academic preparation in science with a college major or minor. This means that 22 percent, or over 40 thousand teachers, do not have adequate preparation in science.

Major/Minor in Field vs. Certification

The percentage of teachers with a major or minor in a field is typically significantly smaller than the percentage certified in the field, if we compare Tables 21, 22, and 23. For example, Kentucky has 98 percent of grade 9–12 math teachers certified and 95 percent of grade 7–8 math teachers certified in math or elementary, but only 79 percent of these teachers have a major or minor in mathematics or math education.

The data on certification reported in Tables 21 and 22 do not differentiate teachers with main assignment in the subject vs. those with second or third assignment to the subject. In many states, the certification rate varies substantially for teachers in their main teaching field as compared to teachers assigned to a second or third field. The rate of certification by field and percent of time assigned is displayed in more detailed tables available from CCSSO.

National Trends in Preparation of High School Teachers: 1988 to 1994

From SASS data over three surveys in seven years we can track the degree of change in the percent of math and science teachers with good academic preparation in their field. The analysis of trends was conducted with only high school teachers (grades 9–12) assigned to math or science for one or more periods ("all teachers" of math and science). The analysis by Ingersoll (1996) also compared the trends in two other teaching fields—English and social studies.

Trends in High School Teachers
Without a Major or Minor in Assigned Field

	Percent Out-of-Field, All Teachers			
	Math	Science	English	Social Studies
1988	28%	16%	23%	17%
1991	31	17	22	17
1994	28	18	22	18

All teachers: Teachers assigned one or more period to field.
Source: NCES, Schools and Staffing Survey, 1988, 1991, 1994.

The percent of high school mathematics and science teachers with major or minor in their assigned field has remained stable since 1988. At the same time, we know from state data that the number of teachers has continued to increase, particularly in mathematics—110 thousand high school math teachers in 1990 to 143 thousand in 1996 (state departments of education reported to CCSSO 1991, 1997). Thus, the number of well-prepared math teachers has increased since 1990 while the percent with a major or minor has remained fairly constant.

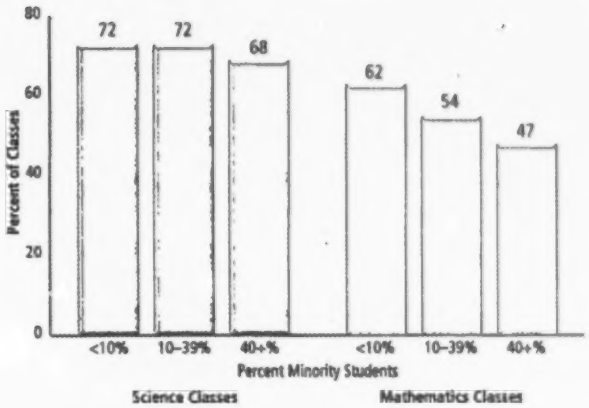
Preparation of Teachers by Student Race/Ethnicity and Poverty Enrollment of School

In reporting indicators of the preparation of teachers in mathematics and science, we need to consider whether variation in teacher preparation is related to the family and community background of students. That is, do certain groups of students get better or less well prepared teachers?

Results from Weiss' 1993–94 survey of a nationally representative sample of elementary and secondary teachers provide statistics on teacher preparation by student race/ethnicity. Figure 9 shows that only 47 percent of mathematics teachers in classes with high minority enrollments have a degree in math or math education. In mathematics classes with less than 10 percent minority students, over 60 percent of teachers majored in

mathematics. Thus, race/ethnicity of students does make a difference in quality of mathematics teachers they are assigned. In science classes, the preparation of teachers differs less according to student race/ethnic composition—in low-minority classes 72 percent of science teachers have science majors, whereas 68 percent of teachers have science majors in high-minority classes (Weiss, 1994).

Figure 9: Percentage of Grades 7–12 Science and Mathematics Classes Taught by Teachers with Major in Field, by Percentage of Minority Students in Class



Source: Weiss, 1994.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Data from the Schools and Staffing Survey analyzed by Ingersoll and Gruber (1996) inform about the proportion of students that are taught by teachers that are not well-prepared certified according to the poverty level of the school. Overall, 27 percent of students in secondary mathematics classes had a teacher without a major or minor in mathematics. In low-poverty schools only 21 percent had a poorly prepared teacher, while 33 percent of students in high-poverty schools had a teacher without a major or minor. In science, the disparity is even greater, with 29 percent of students in high-poverty schools being assigned a teacher without a major or minor in a science field as compared to only 12 percent of students in low-poverty schools.

Percent Teachers Without Major or Minor

	Low Poverty Schools	High Poverty Schools
Mathematics	21%	33%
Science	12	29
Life Science	34	45
Physical Science	50	71

Poverty level = percent of students eligible for free and reduced lunch.

Source: U.S. Department of Education, NCES, Schools and Staffing Survey, 1990–91.

As a national average, students who are taught in classes with high-minority and high-poverty enrollments have less chance of being taught by a teacher who is well prepared in mathematics or science. Unfortunately, this indicator is not available state by state from SASS due to the limitations on sample size. Many states could provide this kind of indicator of teacher preparation by student background for the districts or schools in a state. This information might be more useful to local educators than simply the state average for teachers with a major in their field.

Teachers Professional Development

- ***NCTM Standards:*** **40 percent of teachers in grade 4, and 65 percent of grade 8 math teachers participated in professional development activities aimed at implementing national mathematics standards in the 1995–96 school year.**

- ***Sixteen or more Hours:*** **In 12 states, over 55 percent of eighth-grade mathematics teachers received more than 16 hours of professional development in teaching mathematics in 1995–96.**

Nationally, 48 percent of 8th grade math teachers received more than 16 hours of professional development in teaching mathematics.

Professional standards for teaching mathematics (NCTM, 1991) and standards for teaching science (NRC, 1995) recommend that teachers have adequate course work preparation in the content areas they will be teaching, and in addition the professional organizations recommend ongoing professional development in the subject content and methods of teaching their assigned field and grade level. The 1996 NAEP Mathematics Assessment teacher questionnaire asks teachers at grades 4 and 8 to report on their professional development in mathematics.

Our state indicators in Table 24 focus on two measures of professional development in mathematics. First, we examine the percent of teachers in grades 4 and 8 that have participated in any professional development activities that provided strategies for implementing the 1989 NCTM Curriculum and Evaluation Standards. Second, we examine the amount of professional development grade 4 and 8 teachers report they have received in the last year in workshops or seminars on mathematics or mathematics education.

The data from 1996 NAEP mathematics teacher questionnaire show that a fairly high proportion of elementary and middle level teachers have received some professional development in strategies for implementing NCTM standards for mathematics education. In five states over 60 percent of grade 4 teachers participated in professional development concerning NCTM standards in the year prior to the NAEP survey (Delaware, DODDS, Mississippi, Rhode Island, Vermont). In seven states, over 80 percent of 8th grade math teachers had participated in professional development activities on implementing NCTM standards.

An average of 28 percent of teachers in grade 4 received more than 16 hours of professional development in teaching mathematics. Sixteen or more hours is used as an indicator of teachers' receiving more extensive professional development in teaching math. In five states (Arkansas, California, Nevada, Texas, and Vermont), over 40 percent of 4th grade teachers participated in math professional development at this level. The percent of 8th grade math teachers receiving higher levels of professional development varied by state from only 27 percent of New Mexico teachers to 70 percent of teachers in California and 69 percent in Kentucky.

Table 24: Professional Development of Teachers on Mathematics Education (in last year), 1996 NAEP

STATE	GRADE 4		GRADE 8	
	% Receiving Prof. Dev. on Implementing NCTM Standards	% Receiving 16 or More Hours Prof. Dev.	% Receiving Prof. Dev. on Implementing NCTM Standards	% Receiving 16 or More Hours Prof. Dev.
Alabama	31	24	60	45
Alaska ▽	42	27	60	31
Arizona	39	22	61	43
Arkansas ▽	45	45	68	55
California	36	45	78	70
Colorado	54	21	73	42
Connecticut	44	22	84	47
Delaware	62	22	93	55
Dist. of Columbia	43	27	80	60
DDESS	50	14	93	38
DoDDS	64	28	74	52
Florida	34	30	66	61
Georgia	43	25	69	44
Guam	22	10	33	5
Hawaii	53	30	69	55
Indiana	28	13	67	30
Iowa ▽	53	18	75	35
Kentucky	49	34	76	69
Louisiana	44	31	65	40
Maine	58	28	75	41
Maryland	51	23	81	53
Massachusetts	57	38	81	68
Michigan ▽	41	22	68	44
Minnesota	46	24	74	50
Mississippi	65	37	82	60
Missouri	31	29	71	55
Montana ▽	58	28	77	55
Nebraska	48	23	72	36
Nevada ▽	48	41	—	—
New Jersey ▽	46	22	—	—
New Mexico	43	26	66	27
New York ▽	34	21	61	40
North Carolina	46	19	67	37
North Dakota	53	22	68	44
Oregon	50	24	67	38
Pennsylvania ▽	36	17	—	—
Rhode Island	67	21	79	37
South Carolina ▽	51	27	76	49
Tennessee	34	19	58	36
Texas	29	46	61	64
Utah	58	32	76	46
Vermont ▽	72	41	74	58
Virginia	42	30	76	50
Washington	40	33	68	47
West Virginia	45	20	74	46
Wisconsin	41	18	71	40
Wyoming	46	18	71	34
NATION	**40**	**28**	**65**	**48**

Notes: — Data not available.

▽ Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.

Source: NCES, Data Compendium for the NAEP 1996 Mathematics Assessment (see for standard errors).

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Indicators of Race/Ethnicity and Gender in the Teaching Force

The current distributions and trends in the number of science and mathematics teachers by gender and race/ethnicity provide a basis for states and the nation to compare the characteristics of the current teaching force with goals of improving the match between students and teachers in terms of gender and race/ethnic characteristics.

National survey data (Weiss, 1994; NCES/SASS, 1996) show that minority science and mathematics teachers and female science teachers are vastly under represented, considering the student population in our schools. Oakes' (1990) analysis of teacher characteristics and student participation and opportunities in science and mathematics demonstrated that the rate of participation of minority and female students in science and mathematics is related to the characteristics of their teachers.

Race/Ethnicity of Science and Mathematics Teachers

⇨ **Southeastern states, California, and Hawaii have the highest proportion of science and math teachers that are from minority populations. In most states, the percent minority teachers is one-third or less the percent minority students. The numbers of minority teachers in mathematics and science have increased slightly from 1990 to 1996.**

Since our first state indicators report for 1990, CCSSO has reported state data on the race/ethnicity of high school science and mathematics teachers. As of 1996, we can examine state-by-state percentages of white and minority teachers by subject, as compared to their student populations; and we can observe any trends in increase or decrease in the proportion of minority teachers.

Table 25 ranks the states by the percentage of minority students to show comparisons with the percentage of minority teachers in several fields.

States with the highest proportions of minority teachers in science and mathematics (over 15 percent) are in the Southeast states and Hawaii. Of 18 states with more than 20 percent minority enrollment, only Hawaii comes close to matching the proportions of minority teachers and students. There are not major differences between fields in the percent of teachers that are minorities, although chemistry and physics have slightly fewer minority teachers in most states.

A complete state-by-state disaggregation of teacher race/ethnicity by five race/ethnic groups—African American, Hispanic, Asian American, American Indian/Pacific Islander, white—for each teaching field is available from CCSSO.

The national trends in four high school fields, below, show small increases in the total percent of teachers that are minority teachers in math and science.

Minority Teachers in High School Math and Science: 1990 to 1996

	% Minority Teachers		
FIELD	1990	1994	1996
Mathematics	12%	14%	14%
Biology	11	13	14
Chemistry	7	9	10
Physics	5	6	7

Source: State Departments of Education, 1990–1996.

We know that overall student enrollment of minority students have increased in the U.S. and we know that trends are up in minority enrollments in mathematics and science. Thus, the number of minority teachers is increasing, but at about the same rate as the total number of teachers, and not fast enough to meet the total enrollment of minority students. Currently, 33 percent of K–12 students in our public schools are students from minority populations.

Table 25: Minority Teachers in Mathematics and Science by Minority Students in State, 1996

STATE	Students % Minority	Math % Minority Teachers	Biology % Minority Teachers	Chemistry % Minority Teachers
Maine	2	1	0	0
Vermont	3	—	—	—
New Hampshire	3	—	—	—
West Virginia	4	—	—	—
Nebraska	7	1	1	0
Iowa	8	1	1	1
North Dakota	9	0	1	1
Utah	9	2	1	1
Kentucky	9	2	3	1
Idaho	9	1	1	0
Wyoming	10	2	2	2
Minnesota	11	2	1	0
South Dakota	12	1	1	2
Montana	14	1	0	0
Oregon	14	4	5	—
Indiana	14	3	4	3
Kansas	15	2	3	2
Ohio	16	4	5	3
Wisconsin	18	2	2	2
Missouri	18	5	5	3
Pennsylvania	20	4	4	2
Washington	20	—	—	—
Rhode Island	21	2	6	2
Michigan	21	—	—	—
Massachusetts	21	6	7	3
Connecticut	24	3	5	4
Tennessee	25	11	12	9
Colorado	26	5	6	—
Arkansas	26	9	9	5
Oklahoma	28	5	5	5
Nevada	29	—	—	—
Virginia	30	—	—	—
Illinois	32	10	10	7
NATION	**33**	**13**	**13**	**10**
Alaska	34	—	—	—
Delaware	34	5	3	7
North Carolina	34	14	16	10
New Jersey	34	—	—	—
Alabama	37	15	17	14
Arizona	40	—	—	—
Georgia	41	—	—	—
Florida	41	—	—	—
Maryland	41	—	—	—
New York	42	—	—	—
South Carolina	44	—	—	—
Louisiana	49	—	—	—
Texas	50	20	20	14
Mississippi	51	22	26	24
California	54	21	18	15
New Mexico	60	19	15	15
Hawaii	78	64	49	42
Dist. of Columbia	99	—	—	—
Puerto Rico	100	100	100	100

Notes: — Data not available. Grades 9–12 teachers assigned one or more period to subject. Percent minority teachers = Asian/Pacific Islander, Black, Hispanic, and American Indian teachers. Minority teachers reported under Biology for Colorado = all science; Minnesota = 1994–95 data; Pennsylvania = grades 7–12.

Sources: (Teachers 9–12) State Departments of Education, 1995–96; (Students K–12) NCES, Schools and Staffing Survey, 1993–94.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC , 1997.

Gender of Science and Mathematics Teachers

⇨ **Female teachers of high school mathematics and science have significantly increased in numbers since 1990. For example, 54 percent of mathematics teachers in grades 9–12 are now women, and 43 percent of chemistry teachers are women.**

Figure 10 provides a state-by-state bar graph of the change in percentage of mathematics teachers that are female from 1990 to 1996. The distribution of mathematics teachers by gender varies widely by state, from 31 percent female in Minnesota and 33 percent in Oregon to almost 70 percent female in North Carolina and Alabama.

State data aggregated to the nation indicate that female teachers in mathematics and science in high schools have increased significantly in all fields. For example, the percent female mathematics teachers increased almost 9 percentage points in six years and 10 points in biology. The gender breakdown of math and science teachers by subject since 1990 shows the following trends.

Table 26: Female Teachers in High School Math and Science: 1990 to 1996

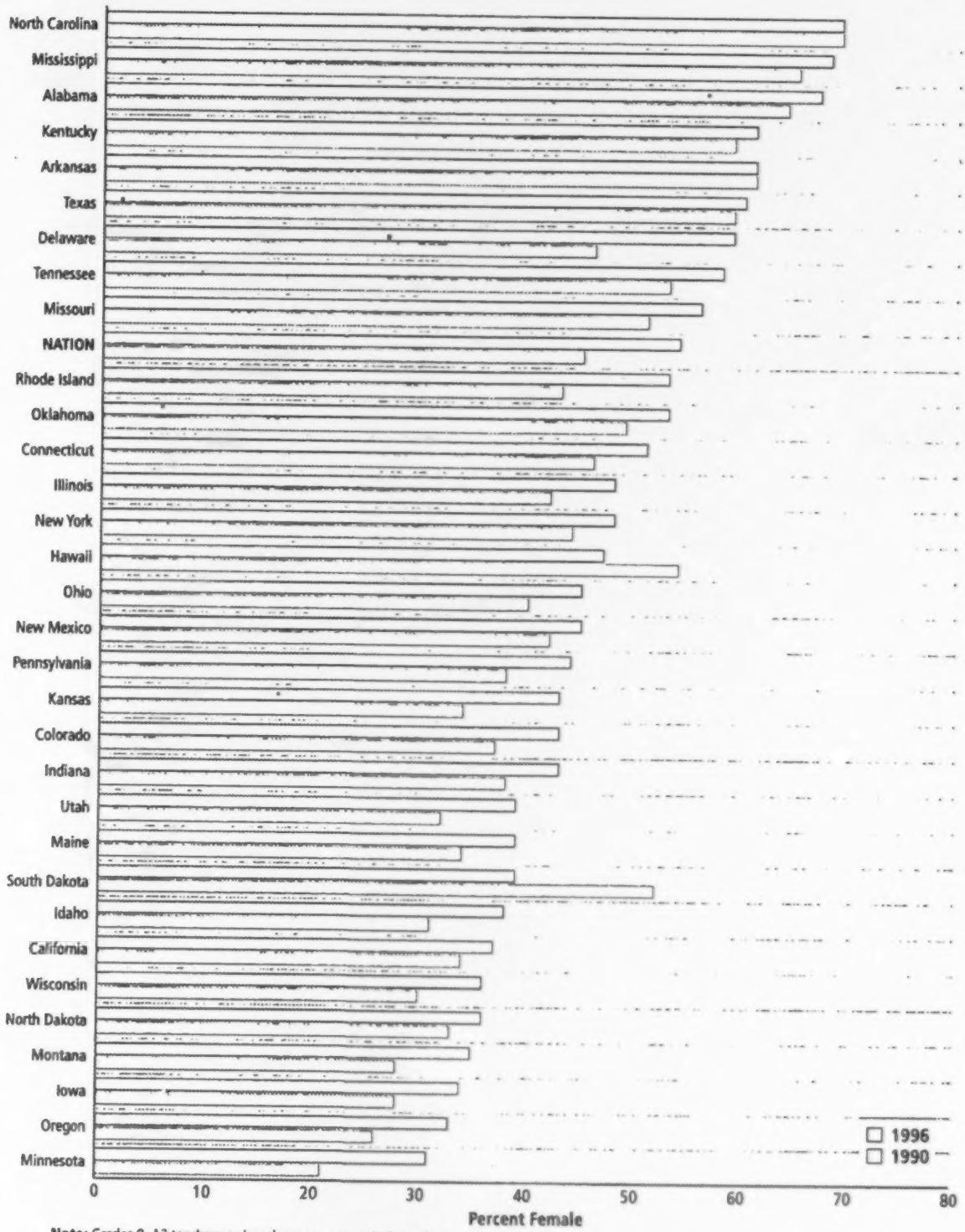
	% Female		
FIELD	1990	1994	1996
Mathematics	45%	49%	54%
Biology	37	42	47
Chemistry	34	37	43
Physics	22	24	28

Over the past six years, a majority of states have increased the percentage of females in math teaching, with the percentage female going up by 5 percentage points in several states, e.g., Delaware, Pennsylvania, Rhode Island, Utah, Minnesota. Two states increased the percentage male (decline in percent female—Hawaii, South Dakota).

The gender distribution of mathematics and science teachers by state shows that geographic region is associated with the pattern across states. Fourteen of the 35 reporting states have more female than male mathematics teachers, and eight are southeastern states. Across all fields, southeastern states have the highest proportion of female high school teachers, and states in the Midwest have the lowest proportion.

The map of chemistry teachers by gender in Figure 11 state shows the regional pattern. Nine states have over 45 percent female chemistry teachers, and all are in the southeast except Puerto Rico. Twelve states have more than one-third female chemistry teachers, and twelve states have from 20 to 32 percent female teachers in chemistry. Data on high school teachers in other fields by state confirm this pattern.

Figure 10: Gender of Mathematics Teachers (Percent Female), 1990 to 1996

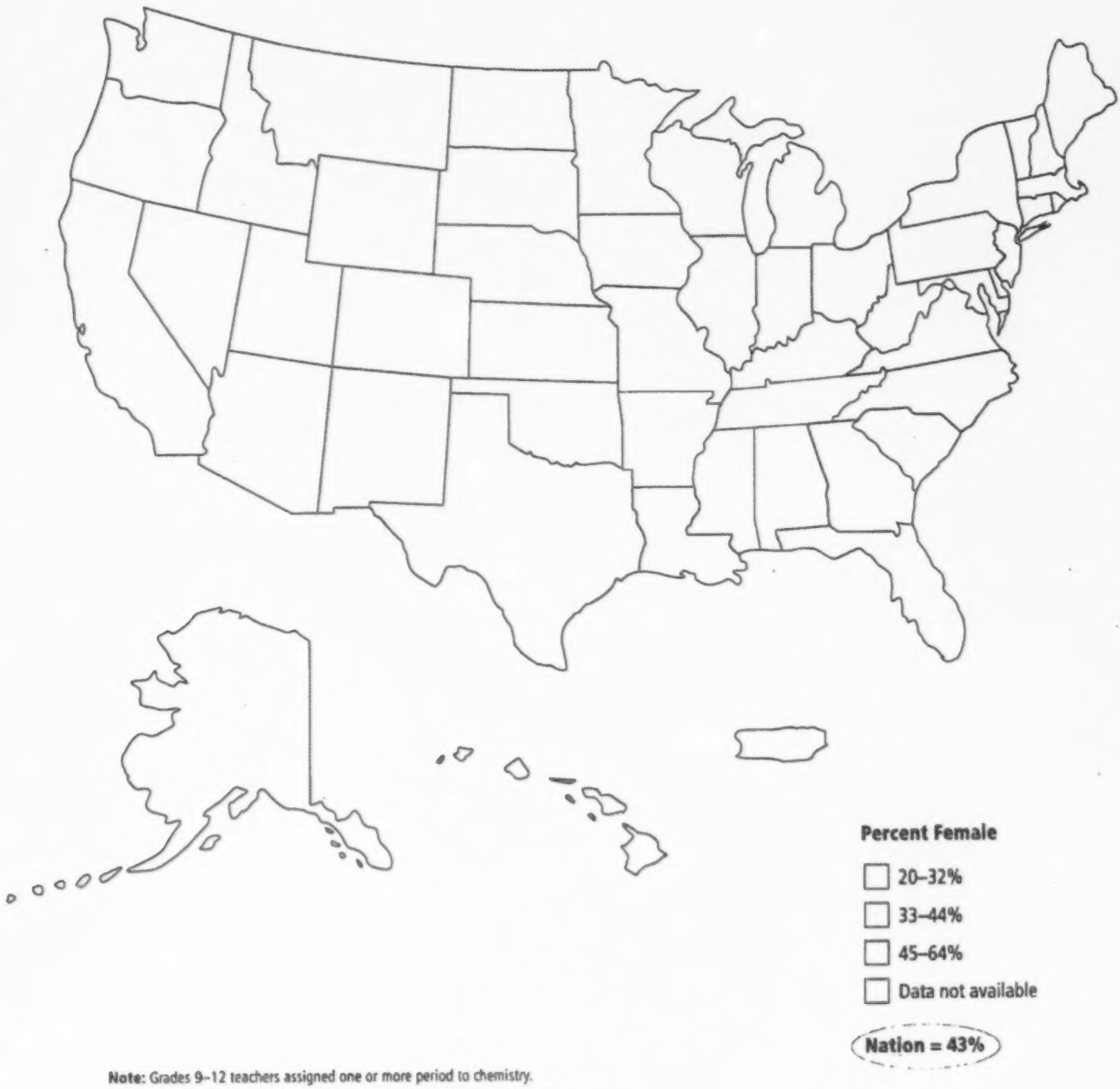


Note: Grades 9–12 teachers assigned one or more period to subject.

Source: State Departments of Education, Data on Public Schools, 1995–96.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Figure 11: Gender of Chemistry Teachers, Percent Female by State, 1996



Note: Grades 9–12 teachers assigned one or more period to chemistry.
Source: State Departments of Education, Data on Public Schools, 1995–96.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Age Distribution of Science and Mathematics Teachers

⇨ **Since 1990, the science and mathematics teaching force has increased in age. The percent of teachers that are over age 50 has gone up over 10 percentage points nationally. At the same time, several states have significantly increased the percent of teachers under age 30 in mathematics and science.**

In 1989–90, states began reporting data to CCSSO on the age distribution of science and mathematics teachers. With 1995–96 data, we have indicators of trends in teacher age by field by state. Teacher data from states are based on the universe of current teachers from state education information systems. Statistics on the percentage of science and mathematics teachers in specific age categories provide useful information for estimating possible shortage fields as teachers near retirement age or leave teaching. Also, we can review the flow of new, younger teachers into these teaching fields.

Teachers Over Age 50 in High School Math and Science: 1990 to 1996

	% Over Age 50		
FIELD	1990	1994	1996
Mathematics	19%	23%	34%
Biology	20	24	33
Chemistry	22	26	28
Physics	23	27	28

Source: State Departments of Education, 1990–1996.

Table 27 shows the percentage of high school mathematics teachers in each state by four age categories, with the states ordered by percentage under age 30. Arkansas, North Carolina, Mississippi, and Kentucky have over 20 percent of mathematics teachers under 30, and all have increased their percentage of younger teachers significantly since 1990. Other states increasing the proportion of mathematics teachers under 30 are Illinois, New Mexico, Minnesota, Delaware, and Rhode Island.

The map in Figure 12 shows the percent of high school mathematics teachers over age 50, and the map reveals that states in the northeast and Midwest have an aging teaching force, with seven states over 30 percent—Pennsylvania, Minnesota, North Dakota, Massachusetts, New York, Connecticut, and Wisconsin have over 30 percent older math teachers. The percentage of teachers over 50 has gone up over 10 points since 1990 (see Table 27) in all of these states plus Ohio, Iowa, Tennessee, Missouri, and North Carolina.

According to NCES projections, attrition rates from elementary and secondary teaching average 10 percent per year, but the period 1995 to 2000 will show higher rates of teacher retirement (NCES, 1997b). States that have flat or declining populations over the past two decades, particularly northeastern and Midwestern states, have higher proportions of older science and mathematics teachers. Many of the teachers over 50 years of age in these states were hired in the 1960s when school enrollments were increasing.

Table 28 shows the percentage of high school physics teachers in each state by four age categories, with the states ordered by percentage under age 30. Five states have over 20 percent of teachers under 30, and six states have less than 10 percent under 30. Also shown is the increase or decrease in the proportion of physics teachers under 30 from 1990 to 1994, and the change in percentage of teachers over 50. We can see that several states have increased the proportion of younger teachers since 1990, including Hawaii, Delaware, Arkansas, Mississippi, New Mexico, and Minnesota.

Thirteen states have over 30 percent physics teachers over age 50 including New York, Ohio, Minnesota, Delaware, Connecticut, Massachusetts, and Wisconsin. The percentage of physics teachers over age 50 has gone up over 10 points since 1990 in Ohio, Rhode Island, Maine, Pennsylvania, North Dakota, Kansas, and Kentucky.

Table 27: Age of Mathematics Teachers, 1990 to 1996

STATE	% Under Age 30	Change % Under 30 1990 to 1996	% Age 50 & Over	Change % Over 50 1990 to 1996
Arkansas	27	+13	10	-5
North Carolina	25	+5	20	+10
Mississippi	22	+8	16	-1
Kentucky	22	+3	16	+6
Alabama	20	+7	18	+5
Kansas	20	-2	27	+6
Illinois	20	+9	27	+4
Missouri	19	0	25	+10
Nebraska	19	—	25	—
South Dakota	18	0	26	+4
Utah	18	+2	24	+2
Idaho	18	+1	23	+4
New Mexico	18	+6	18	-2
Hawaii	19	+5	16	-1
Indiana	17	+2	25	+8
Oklahoma	17	0	15	+4
Iowa	17	+2	28	+10
Tennessee	16	+1	24	+10
Minnesota	16	+6	34	+5
Wyoming	15	—	26	—
Montana	15	+2	25	+6
Delaware	15	+6	27	-1
NATION	**15**	**+2**	**21**	**+2**
North Dakota	14	-8	21	+8
Wisconsin	14	+1	30	+9
Maine	13	-1	23	+8
Ohio	13	-3	29	+16
California	12	-1	29	+3
Oregon	12	0	22	0
Colorado	11	+2	27	+5
Pennsylvania	11	+2	35	+16
New York	11	+2	31	+11
Rhode Island	10	+7	24	+9
Massachusetts	10	—	33	—
Connecticut	7	+1	36	+16
Puerto Rico	3	—	18	—

Notes: — Data not available. Grades 9–12 teachers assigned one or more period to subject.

Source: State Departments of Education, Data on Public Schools, 1995–96.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Figure 12: Mathematics Teachers Age 50 and Over, by State, 1996

Source: State Departments of Education, Data on Public Schools, 1995–96.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Table 28: Age of Physics Teachers, 1990 to 1996

STATE	% Under Age 30	Change % Under 30 1990 to 1996	% Age 50 & Over	Change % Over 50 1990 to 1996
Puerto Rico	25	—	22	—
Hawaii	29	+12	13	-9
Delaware	24	+7	34	+5
Kentucky	20	+4	22	+10
Arkansas	20	+7	12	-10
Alabama	18	+2	19	+1
Nebraska	18	—	27	—
North Carolina	17	+2	24	+7
Mississippi	16	+7	25	+5
New Mexico	16	+6	9	-8
Iowa	15	-1	28	+7
Illinois	15	+3	28	-4
South Dakota	15	-7	25	+7
Indiana	14	+1	31	+6
Minnesota	13	+5	38	+5
NATION	**13**	**+2**	**28**	**+5**
Wisconsin	12	+3	35	+5
Pennsylvania	12	+2	38	+12
Kansas	12	-2	34	+11
Missouri	11	-3	26	+5
Montana	11	-5	25	+8
Oklahoma	11	+4	22	+4
Idaho	10	-3	25	-6
Tennessee	10	+1	30	+9
California	10	-4	27	+5
New York	10	+3	35	+8
North Dakota	10	-4	26	+10
Massachusetts	9	—	40	—
Ohio	7	-6	35	+21
Utah	7	-3	29	+10
Connecticut	5	-2	39	+10
Maine	5	-8	34	+13
Rhode Island	1	-1	31	+13

Notes: — Data not available. Grades 9–12 teachers assigned one or more period to subject.

Source: State Departments of Education, Data on Public Schools, 1995–96.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

New Teachers in Math and Science

- **Eight states had over 8 percent new, first-year high school mathematics teachers in 1995–96; another eight states had 3 percent or less new teachers in math. Nationally, 7 percent of all high school mathematics teachers were first-year teachers.**

- **In science, only three states had more than 8 percent new first-year high school teachers, while 15 states had 3 percent or less new science teachers. For the nation, 5 percent of all high school science teachers were new first-year teachers.**

An important indicator of teacher supply in science and mathematics is the number of new teachers entering teaching. The data on age of the current teaching force by state show that almost half the states will have one-third or more of their high school science and math teachers retiring in the next few years. The data also show that several states have significant numbers of younger teachers under age 30. With the current increases in student enrollments experienced by most states additional new teachers will be needed in science and mathematics.

In 1995–96, 30 states were able to report data on the number of new teachers in science and mathematics.

Table 29 provides two indicators of the number of new high school science and mathematics in each state. We show the percent of all science and math teachers that are new, first-year teachers in each state during the 1995–96 school year.

The table also shows the percent of all teachers in each state that are newly hired in their district but are experienced, returning teachers. This indicator shows the proportion of teachers that were newly hired in 1995–96 but have some prior experience and were not teaching in the state the previous year.

States with high numbers of new teachers in *mathematics* last year were: Alabama (9%), Idaho (15%), Mississippi, North Carolina, Utah (14%), and South Dakota (18%). In Alabama, Idaho, and Massachusetts, 5 percent of mathematics teachers last year were newly hired and returning to teaching. Other reporting states had from one to 4 percent returning teachers in mathematics.

In *science*, states with high numbers of new teachers last year were: Idaho (12%), North Carolina (10%) and Utah (13%). No state had over 4 percent returning experience teachers in science, with most states reporting from one to three percent in this category.

Table 29: New Teachers in High School Science and Mathematics, 1996

STATE	NEW FIRST-YEAR TEACHERS				RETURNING TEACHERS	
	Math New	% New	Science New	% New	Math %	Science %
Alabama	164	9%	84	5%	5%	4%
Alaska	—	—	—	—	—	—
Arizona	—	—	—	—	—	—
Arkansas	253	8	76	6	—	—
California	601	6	297	4	—	—
Colorado	76	5	48	4	—	—
Connecticut	36	2	42	2	2	2
Delaware	5	2	6	5	1	2
Dist. of Columbia	8	3	3	2	—	—
Florida	—	—	—	—	—	—
Georgia	—	—	—	—	—	—
Hawaii	—	—	—	—	—	—
Idaho	136	15	83	12	5	3
Illinois	209	5	95	2	2	1
Indiana	90	4	78	3	3	3
Iowa	58	4	58	3	3	3
Kansas	—	—	—	—	—	—
Kentucky	111	7	62	4	4	3
Louisiana	—	—	—	—	—	—
Maine	20	3	10	1	—	—
Maryland	—	—	—	—	—	—
Massachusetts	113	4	79	3	5	4
Michigan	—	—	—	—	—	—
Minnesota	77	4	70	4	1	0.2
Mississippi	166	14	79	6	—	—
Missouri	—	—	—	—	—	—
Montana	—	—	—	—	—	—
Nebraska	—	—	—	—	—	—
Nevada	—	—	—	—	—	—
New Hampshire	—	—	—	—	—	—
New Jersey	—	—	—	—	—	—
New Mexico	40	5	17	2	4	4
New York	149	2	285	2	2	1
North Carolina	636	14	288	10	3	2
North Dakota	6	1	15	3	4	3
Ohio	175	4	114	3	—	—
Oklahoma	105	6	75	4	2	2
Oregon	33	3	8	3	4	2
Pennsylvania	186	3	122	3	—	—
Puerto Rico	116	4	37	3	—	—
Rhode Island	—	—	—	—	—	—
South Carolina	—	—	—	—	—	—
South Dakota	103	18	31	5	1	1
Tennessee	—	—	—	—	—	—
Texas	1,947	8	1,040	7	4	2
Utah	200	14	127	13	—	—
Vermont	—	—	—	—	—	—
Virginia	—	—	—	—	—	—
Washington	—	—	—	—	—	—
West Virginia	—	—	—	—	—	—
Wisconsin	76	3	70	3	1	2
Wyoming	—	—	—	—	—	—
NATION		7		5		

Notes: — Data not available. New = No experience; Returning = one or more years experience, not teaching in state prior year. Minnesota: 1994–95 data.

Source: State Departments of Education, Data on Public Schools, 1995–96.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

- ◇ **Students per Teacher in Mathematics and Science**
- ◇ **Average Class Size in Mathematics and Science**
- ◇ **Instructional Resources and Materials**

State data on course enrollments show that nationally the proportion of public high school students taking a mathematics course increased from 87 percent in 1992 to 92 percent in 1996. The 92 percent enrollment figure represents a total of 11.1 million high school students taking mathematics. The total is an increase of 1.1 million students taking mathematics, while the high school teaching force in mathematics increased by 7,000 teachers (FTE) over the four-year period.

In science, total enrollments increased from 75 percent of high school students taking science in 1992 to 82 percent in 1996, an increase of 1.3 million students. During the period, the total number of teachers in high school science increased by 11,000 teachers (FTE). The following table summarizes change in numbers of teachers and students over four years.

	1992		1996	
Grades 9–12	Math	Science	Math	Science
Students Enrolled	10.0M	8.65M	11.1M	9.95M
Teachers (FTE)	98.4K	91.3K	105.3K	102.3K

Source: State Departments of Education, 1992, 1996.

These data give us a picture of the overall size of mathematics and science education at the high school level, and inform us that the total enterprise is increasing significantly each year. To provide useful information to policymakers and educators, we would like to have more specific indicators about the specific conditions for teaching in science and mathematics in our states, districts, and schools.

POLICY ISSUES

- ◦ Do school systems have a sufficient number of science and mathematics teachers to provide high quality teaching to students?
- ◦ Do teachers have adequate resources and materials to meet standards for science and mathematics instruction?

Students per Teacher in Mathematics and Science

- ⇨ **In high school mathematics, 6 states have student/teacher ratios of over 125 to one, while 10 states have ratios of less than 100 to one.**
- ⇨ **In chemistry teaching, 6 states have student/teacher ratios of over 125 to one, and 13 states have ratios of less than 100 to one.**

An indicator of conditions for teaching and learning mathematics and science is a ratio of the number of students in each subject to the number of teachers. This indicator provides a basic picture of how many students the average teacher in a state must work with during a given school day or week, and the state gains a general estimate of the current supply of teachers for the enrollment demands from students. To estimate the ratio, we use the number of FTE teachers and the total number of students taking mathematics and science courses in high school.

Table 30 reports students per teacher ratios for math and three science subjects for 1995–96. A high ratio (e.g., West Virginia, 181 students per math teacher) means that teachers have to work with more students on a daily basis than teachers in a state with a lower ratio (e.g., South Dakota at 88). In chemistry, the student teacher ratios vary from a high of 216 students per FTE teacher in West Virginia to a low of 72 students per teacher in Oklahoma.

Table 30: Students per Teacher in Mathematics and Science, Grades 9–12

STATE	MATH		BIOLOGY		CHEMISTRY		PHYSICS	
	All Teachers	Students/ FTE Teacher	All Teachers	Students/ FTE Teacher	All Teachers	Students/ FTE Teacher	All Teachers	Students/ FTE Teacher
Alabama	1,747	104	927	104	407	94	274	79
Alaska	—	—	—	—	—	—	—	—
Arizona	—	—	—	—	—	—	—	—
Arkansas	3,074	95	612	113	348	110	234	195
California	9,727	144	3,693	137	1,587	135	1,006	127
Colorado	1,382	—	1,236	—	—	—	—	—
Connecticut	1,527	90	737	83	401	79	278	76
Delaware	206	132	60	160	27	197	29	54
Dist. of Columbia	—	—	—	—	—	—	—	—
Florida	—	—	—	—	—	—	—	—
Georgia	—	—	—	—	—	—	—	—
Hawaii	825	70	200	100	90	92	56	71
Idaho	880	106	302	113	134	114	99	77
Illinois	4,208	111	1,680	122	1,115	103	714	94
Indiana	2,356	112	1,133	107	592	95	407	85
Iowa	1,501	—	734	—	421	—	360	—
Kansas	996	—	600	—	381	—	257	—
Kentucky	1,618	120	752	116	424	106	226	98
Louisiana	1,524	124	613	113	214	153	108	166
Maine	635	—	318	—	191	—	155	—
Maryland	—	—	—	—	—	—	—	—
Massachusetts	2,662	90	1,046	84	630	75	417	66
Michigan	—	—	—	—	—	—	—	—
Minnesota	1,885	112	827	120	513	108	390	95
Mississippi	1,147	124	753	117	321	93	213	73
Missouri	2,235	114	1,193	102	626	95	395	72
Montana	555	96	290	105	168	96	147	67
Nebraska	1,266	82	593	90	316	81	279	62
Nevada	—	—	—	—	—	—	—	—
New Hampshire	579	—	205	—	76	—	39	—
New Jersey	—	—	—	—	—	—	—	—
New Mexico	741	121	376	106	154	100	92	83
New York	7,901	104	5,538	59	2,044	78	1,202	70
North Carolina	4,412	112	1,322	118	606	110	346	88
North Dakota	457	88	256	98	166	91	126	61
Ohio	4,790	118	1,971	110	1,084	98	767	83
Oklahoma	1,897	82	1,033	78	492	72	270	52
Oregon	991	118	296	123	—			
Pennsylvania	6,557	89	1,990	99	1,137	101	737	85
Puerto Rico	2,628	68	513	73	319	78	227	50
Rhode Island	694	—	185	—	101	—	67	—
South Carolina	—	—	—	—	—	—	—	—
South Dakota	570	88	291	87	192	76	154	57
Tennessee	2,282	111	1,111	89	470	101	246	88
Texas	23,947	74	8,692	59	2,441	86	1,330	66
Utah	1,395	132	530	150	147	191	90	221
Vermont	—	—	—	—	—	—	—	—
Virginia	—	—	—	—	—	—	—	—
Washington	—	—	—	—	—	—	—	—
West Virginia	1,240	181	257	195	128	216	52	215
Wisconsin	2,218	139	970	131	589	124	414	106
Wyoming	264	—	107	—	60	—	—	—
NATION	**142,721**		**58,088**		**25,459**		**16,047**	

Notes: — Data not available.
Students per teacher ratio based on number of students enrolled in subject divided by estimated number of FTE teachers assigned to subject.
All Teachers = one or more period assigned to subject.
Delaware: main assignment only; Minnesota: 1994–95 data; Pennsylvania: grades 7–12.

Source: State Departments of Education, Data on Public Schools, 1995–96.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

83

The total number of teachers assigned to each subject in Table 30 can be compared to the number of high schools in each state (see Appendix A.9). From this comparison a general picture can be gained of the degree to which all students have a teacher assigned in each field, particularly in the fields of chemistry and physics.

Average Class Size in Mathematics and Science

- **Class size in high school mathematics varies across the states from 18 students per class to 28 students per class, with the average class at 23 students.**

- **Science classes in high schools vary by state from 18 students per class to 29 students per class, with the average at 24 students.**

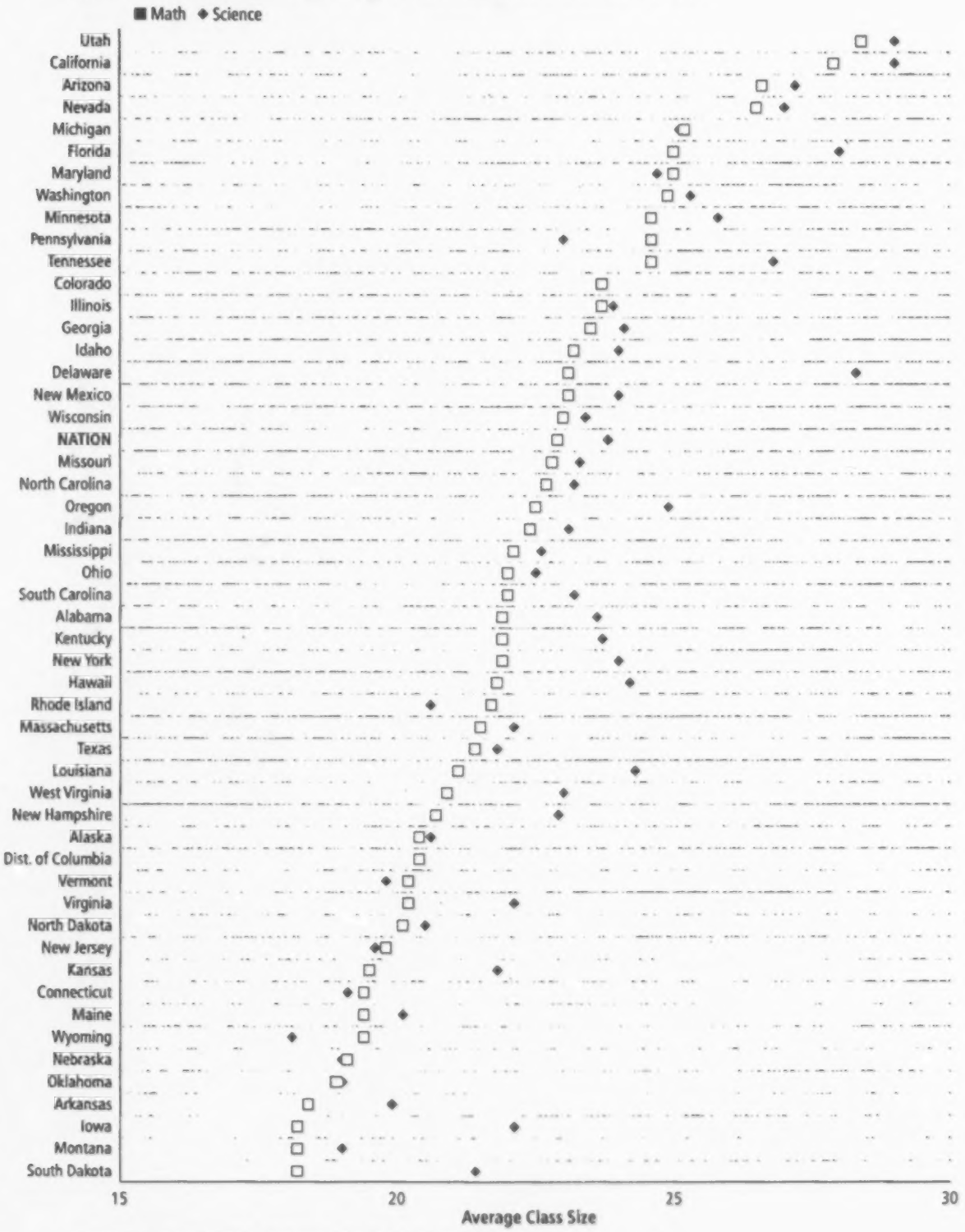
Data from the 1994 Schools and Staffing Survey provide a state indicator of average class size in high school mathematics and science. This indicator gives a picture of what the typical teacher deals with in instructing high school science or mathematics classes.

Figure 13 indicates that the average mathematics class size varies by state from 18 students per class in Montana, South Dakota, and Iowa to 28 students per class in Utah and California. Thus, high school mathematics teachers work with over 50 percent larger classes in several high-growth states. Figure 13 also indicates that the average science class varies by state from 18 students per class in Wyoming and 19 students in Nebraska and Montana to 29 students in Utah and California.

From 1988 to 1994, the average mathematics class size increased by two students per class to 23 students in 1994. The average class size in science also increased by two from 22 to 24 students per class.

Further statistics on class size are reported in Appendix A. State averages were computed from SASS data for advanced math classes and for biology classes, to provide a comparison with all math classes and all science classes. In addition, the percentage of math and science classes with more than 30 students is reported by state. These statistics provide further depiction of the range of class sizes within states. For example, some states have a high percentage of classes over 30 students in advanced mathematics (Florida, California, Utah, Arizona), and these sizes are significantly over the average for the nation or the state.

Figure 13: Average Class Size in High School Mathematics and Science, 1994



Source: NCES Schools and Staffing Survey, Public School Teachers, 1993–94.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

90

Instructional Resources for Mathematics and Science

- **In 35 percent of grade 4 classrooms one computer is available for mathematics and science instruction, and 29 percent have two or more computers available; only 6 percent have no computers available. In mathematics instruction, the most common use of computers is playing mathematical learning games.**

- **The average elementary school spends about 50 cents per student on science consumable supplies (e.g., chemicals, batteries, glassware) per year, and the average middle school spends less than one dollar per student on science supplies.**

The NAEP 1996 teacher questionnaire asked teachers to report on the availability of computers for instruction and their primary use in the classroom. The results by state for grade 4 classes are reported in Table 31. Most grade 4 classes (64 percent) have a computer in the classroom. Almost 30 percent of teachers reported computers are available in a computer laboratory room in the school, and six percent nationally reported no computers are available for students use. In three states over 20 percent of classes had no computers.

In grade 4 mathematics, over 40 percent of teachers reported the primary use of computers in instruction was in students playing mathematical learning games. Another 27 percent of classes use computers primarily for drill and practice in mathematics.

In grade 8 mathematics classes, 26 percent of math classrooms, nationally, have no computers available, and 31 percent have a computer in the classroom, as shown in Table 32. The remaining teachers reported computers are available in a computer lab. Among the teachers reporting some use in instruction, 18 percent of grade 8 classes primarily use them for drill and practice, and 13 percent use them for simulations and applications.

A 1993 national survey on science and mathematics education (Weiss, 1994) supported by NSF provided national data on availability of instructional materials and resources for science. (State-level data on science resource issues will be available soon from the NAEP 1996 Science results.) The nationally-representative survey asked elementary school principals and middle school and high school department heads to report on school conditions and support for science and math teaching and the availability and use of materials and resources. The survey included specific questions on the amount of money that was spent annually on science and mathematics books, materials, supplies and equipment.

The average elementary school spent only $0.51 per student on science consumable supplies (e.g., chemicals, batteries, glassware), and the typical middle school spent only $0.88 per student. In mathematics, the average elementary school spent only $1.00 per student on math manipulatives and other materials, and middle schools averaged only $0.40 per student on mathematics materials.

The average school spent only $50 on science computer software and $100 on mathematics software, and we know that the price of one piece of software is about $100. These data on average expenditures clearly show why teachers reported that lack of resources and materials is a key problem in science instruction.

Expenditures for Type of Resources and Materials

	Average Annual Spending	
Computer software—Mathematics	$100.00	per school
Computer software—Science	$50.00	per school
Science supplies—Elementary	$0.51	per student
Science supplies—Middle grades	$0.88	per student
Math manipulatives—Elementary	$1.00	per student
Math materials—Middle grades	$0.40	per student

Source: Weiss, 1994.

Table 31: Availability and Use of Computers in Mathematics Instruction, Grade 4, 1996 NAEP

STATE	COMPUTER AVAILABILITY % OF STUDENTS			PRIMARY COMPUTER USE % OF STUDENTS	
	None	One per Classroom	Two or More per Classroom	Drill and Practice	Playing Mathematical/ Learning Games
Alabama	10	42	30	40	40
Alaska ▽	7	21	39	21	45
Arizona	12	22	19	30	36
Arkansas ▽	9	20	18	50	19
California	6	25	30	24	47
Colorado	4	31	29	34	37
Connecticut	7	34	41	28	40
Delaware	18	33	16	18	35
Dist. of Columbia	16	30	19	30	33
DDESS	6	14	51	35	38
DoDDS	1	23	66	13	59
Florida	4	28	52	38	38
Georgia	3	31	45	42	36
Guam	20	0	3	43	8
Hawaii	8	46	30	19	40
Indiana	1	14	42	52	30
Iowa ▽	3	35	30	38	47
Kentucky	4	24	39	31	36
Louisiana	21	29	14	32	24
Maine	7	42	26	23	45
Maryland	5	17	30	40	29
Massachusetts	6	37	27	22	44
Michigan ▽	8	34	28	31	39
Minnesota	5	27	16	34	40
Mississippi	20	12	16	35	18
Missouri	12	31	14	28	39
Montana ▽	5	27	27	21	47
Nebraska	2	35	35	47	40
Nevada ▽	10	32	14	31	42
New Jersey ▽	14	43	13	30	33
New Mexico	11	25	34	22	48
New York ▽	13	27	25	31	35
North Carolina	6	22	35	34	34
North Dakota	2	29	28	34	45
Oregon	8	35	27	26	38
Pennsylvania ▽	13	21	28	30	29
Rhode Island	13	44	33	22	45
South Carolina ▽	8	30	19	36	30
Tennessee	9	33	40	32	40
Texas	7	24	22	37	33
Utah	7	15	16	31	39
Vermont ▽	7	20	47	18	38
Virginia	3	34	32	38	45
Washington	5	27	34	27	42
West Virginia	2	8	70	59	22
Wisconsin	5	24	28	28	46
Wyoming	3	11	24	35	38
NATION	**6**	**35**	**29**	**27**	**41**

Notes: Other availability = in computer lab; Other use = demonstrate new topics, simulations.
Data from teacher reports on computer availability and primary use.

▽ Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.

Source: NCES, Data Compendium for the NAEP 1996 Mathematics Assessment (see for standard errors).

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

92

Table 32: Availability and Use of Computers in Mathematics Instruction, Grade 8, 1996 NAEP

STATE	COMPUTER AVAILABILITY % OF STUDENTS			PRIMARY COMPUTER USE % OF STUDENTS	
	None	One per Classroom	Two or More per Classroom	Drill and Practice	Simulations and Applications
Alabama	31	21	12	22	5
Alaska ▽	11	28	22	4	8
Arizona	25	22	10	12	15
Arkansas ▽	40	12	11	19	5
California	22	21	12	4	12
Colorado	12	19	8	15	15
Connecticut	22	13	7	12	18
Delaware	45	20	11	2	10
Dist. of Columbia	17	10	32	24	26
DDESS	2	12	64	21	21
DoDDS	11	22	36	4	21
Florida	21	26	18	17	12
Georgia	15	27	14	18	10
Guam	53	0	8	25	0
Hawaii	20	26	10	8	5
Indiana	19	12	11	18	14
Iowa ▽	11	22	10	7	18
Kentucky	5	22	15	15	23
Louisiana	43	10	10	17	3
Maine	13	23	11	6	19
Maryland ▽	7	8	5	37	16
Massachusetts	23	19	5	5	14
Michigan ▽	23	19	8	6	14
Minnesota	10	21	8	8	21
Mississippi	37	15	7	24	2
Missouri	18	13	14	16	16
Montana ▽	6	14	24	7	35
Nebraska	12	24	7	5	14
New Mexico	32	21	9	16	7
New York ▽	28	5	6	12	15
North Carolina	12	16	11	27	16
North Dakota	13	20	10	14	20
Oregon	22	26	8	2	16
Rhode Island	15	7	0	6	13
South Carolina ▽	21	20	11	26	5
Tennessee	22	24	30	21	8
Texas	21	21	13	26	14
Utah	32	16	8	13	8
Vermont ▽	11	27	18	10	25
Virginia	8	20	8	22	21
Washington	18	29	13	7	17
West Virginia	23	12	17	20	2
Wisconsin ▽	12	19	5	8	19
Wyoming	10	19	22	13	10
NATION	**26**	**19**	**12**	**18**	**13**

Notes: Other availability = in computer lab; Other use = demonstrate new topics, math/learning games. Data from teacher reports on computer availability and primary use.

▽ Indicates jurisdiction did not satisfy one or more of the guidelines for school participation rates.

Source: NCES, Data Compendium for the NAEP 1996 Mathematics Assessment (see for standard errors).

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Educators and policymakers who read reports providing statistical indicators on education are faced with the question of how to interpret the statistics in relation to current questions about the quality of education and how to use the indicators to examine current and proposed policy initiatives. The science and mathematics indicators outlined in this report can be helpful in analyzing education policies at state, national, and local levels. Following are suggestions for use of the indicators in analyzing education policies.

The intent of the Council and NSF is to provide a report of science and mathematics indicators that would meet a variety of needs for information. At the same time, our decisions on how indicators are selected, designed, and presented in the report does shape how the information can be used.

We chose *not* to compute and provide a composite indicator that would give a summary score for states across a number of individual indicators. The development of educational indicators has not reached the level of consensus among policymakers, researchers, and educators to make effective use of such a composite indicator. State users of indicators have expressed strong interest in having indicators reported individually to allow for different applications and interpretations.

We continue to hear expressed a need for indicators in at least three broad categories: (a) student achievement and outcomes; (b) school processes, content, and instructional practices; and (c) conditions or context for teaching and learning. Since our work on science and mathematics indicators began in 1986, several individual indicators have developed, changed, or been added, but these broad categories continue to be used.

Uses for analyzing education policies are central to the design for the 1997 report. First, we report state-by-state results on student achievement. The Council voted in 1984 to support state-by-state reporting of state achievement results if they are valid, comparable, and reliable. In this report, the statistics on NAEP mathematics and science assessments and advanced placement examinations in this report allow the reader to analyze state-to-state differences in achievement and examine trends for individual states. In addition, student scores are reported in relation to standards for performance, that is, the knowledge and skills students should have by a given grade level.

Policy reforms in the 1980s aimed to increase the amount of time in elementary and secondary school that students study core academic subjects, such as mathematics and science. High school enrollments in science and mathematics are compared across different levels of state requirements, and trends are reported since 1990. We chose to report the rate at which students are progressing to higher-level courses in science and mathematics, not just the number of credits or courses. This approach to reporting indicators of course taking is consistent with a standard of all students learning challenging subject content in science and mathematics by graduation. This standard reflects the direction many states are now taking toward reform of mathematics and science.

Our analysis of state course enrollments also addresses grade 7 and 8 math and science, where there is currently concern about the lack of focus and extensive breadth of curriculum being taught.

States are currently examining policies and programs concerning initial preparation and professional development of teachers and administrators. An important issue is the use of state standards for content knowledge and instructional skills to guide preparation of educators. This report applies one standard of preparation whether secondary science and mathematics teachers have a major in their assigned teaching field. We also report on the proportion of teachers that have state certification in their assigned field, and we analyze the rate of certification for middle-level and high school teachers. Finally, we report state indicators from NAEP 1996 on teacher professional development with NCTM standards and the amount of time spent on professional development.

94 c9

Science and mathematics education reform emphasizes learning through doing and active involvement of students in application of knowledge, hands-on laboratory experiences, and projects. The 1997 indicators provide reliable information on use of calculators and writing in math. We also report data on trends in use of computers and availability of classroom resources and materials in science and mathematics to support active instruction. The indicators can have a role in examining policies that would provide support for science and mathematics reform efforts through key resources and materials.

The format of the 1997 CCSSO report is intended to assist in the use of state indicators, such as inclusion of full-page tables and graphics that can be photocopied as transparencies. We also provide detailed state-level data in a series of Appendixes which are available on diskette. Several key indicators are reported for large cities participating in the Urban Systemic Initiatives supported by NSF. State Profiles on Science and Math Indicators are available to all users in electronic form, on our Internet web site (www.ccsso.org/standards_and_assessments/state_profiles/).

List of Abbreviations

AAAS	American Association for the Advancement of Science
AP	Advanced Placement
CCSSO	Council of Chief State School Officers
ECS	Education Commission of the States
ETS	Educational Testing Service
FTE	Full-Time Equivalent
NAEP	National Assessment of Educational Progress
NCES	National Center for Education Statistics, U.S. Department of Education
NCEST	National Council on Education Standards and Testing
NCTM	National Council of Teachers of Mathematics
NEGP	National Education Goals Panel
NGA	National Governors' Association
NRC	National Research Council
NSF	National Science Foundation
NSTA	National Science Teachers Association
OERI	Office of Educational Research and Improvement, U.S. Department of Education
PSA	Policy Studies Associates
SASS	Schools and Staffing Survey
SES	Socioeconomic status
SSI	Statewide Systemic Initiatives
TIMSS	Third International Mathematics and Science Study
USI	Urban Systemic Initiatives

References

American Association for the Advancement of Science (1993). *Benchmarks for science literacy.* New York: Oxford University Press.

Blank, R.K. (1993). Developing a system of education indicators: selecting, implementing, and reporting indicators. *Educational Evaluation and Policy Analysis, 15(1),* pp. 65-80.

Blank, R.K., & Dalkilic, M. (1991). *State indicators of science and mathematics education: 1990.* Washington, DC: CCSSO, State Education Assessment Center.

Blank, R.K., & Dalkilic, M. (1992). *State policies on science and mathematics education: 1992.* Washington, DC: CCSSO, State Education Assessment Center.

Blank, R., & Espenshade, P. (1988). 50-State analysis of education policies on science and mathematics. *Educational Evaluation and Policy Analysis, 10*(4). pp. 315-324.

Blank, R.K., & Gruebel, D. (1993). *State indicators of science and mathematics education 1993. State and national trends: new indicators from the 1991-92 school year.* Washington, DC: CCSSO, State Education Assessment Center.

Blank, R.K., & Gruebel, D. (1995). *State indicators of science and mathematics education 1995. State-by-state trends and new indicators from the 1993-94 school year.* Washington, DC: CCSSO, State Education Assessment Center.

Blank, R.K., Langesen, D., Bush, M., Sardina, S., Pechman, E., & Goldstein, D. (1997). *Mathematics and science content standards and curriculum frameworks. States progress on development and implementation.* Washington, DC: CCSSO, State Education Assessment Center.

Blank, R. K., & Pechman, E. (1995). *State curriculum frameworks in mathematics and science. How are they changing across the states?* Washington, DC: CCSSO, State Education Assessment Center.

Bond, L.A., Roeber, E., & Braskamp, D.C. (1997). *Data on statewide student assessment programs in the United States.* Washington, DC: CCSSO; Oak Brook, IL: North Central Regional Education Laboratory.

California Scope, Sequence, & Coordination Project (1995). *Restructuring science education in California.* Sacramento, CA: California Department of Education.

Campbell, J.R., Reese, C.M., O'Sullivan, C., & Dossey, J.A. (1996). *NAEP 1994 Trends in Academic Progress.* Washington, DC: U.S. Department of Education, National Center for Education Statistics.

College Board (1996). *Advanced Placement Program: National and 50 states summary reports.* New York, NY: Author.

Council of Chief State School Officers (1985). *Assessment and evaluation plan of the Committee on Coordinating Education Information and Research.* Washington, DC: Author.

Council of Chief State School Officers (1993). *Analysis of state education indicators: State profiles and NAEP results related to state policies and practices* (with J.A. Dossey). Washington, DC: CCSSO, State Education Assessment Center.

Council of Chief State School Officers (1995). *Instructions and reporting forms for data on science and mathematics education in (each state).* Washington, DC: CCSSO, State Education Assessment Center.

Council of Chief State School Officers (1996). *Key state education policies on K–12 education.* Washington, DC: State Education Assessment Center.

Goodlad, J.I. (1984). *A place called school: Prospects for the future.* New York: McGraw-Hill.

Horn, L. & Hafner, A. (1992). *A profile of American eighth-grade mathematics and science instruction.*

Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Husen, T. (Ed.) (1967). *International study of achievement in mathematics: A comparison of twelve countries* (Vols. 1 and 2). New York: John Wiley.

Ingersoll, R.M., & Gruber, K. (1996). *Out-of-field teaching and educational equality.* Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Jones, L.R., Mullis, I.V.S., Raizen, S.A., Weiss, I.R., & Weston, E.A. (1992). *The 1990 science report card: NAEP's assessment of fourth, eighth, and twelfth grades.* Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Jones, L.V., Davenport, E.C., Bryson, A., Bekhuis, T., & Zwick, R. (1986). Mathematics and science test scores as related to courses taken in high school and other factors. *Journal of Educational Measurement, 23*(3), 197-208.

Kominski, R. (1993). *School enrollment, social and economic characteristics of students: October 1993.* Current Population Reports, Series P-20, No. 413. Washington, DC: U.S. Bureau of Census.

Lee, V.E., Bryk, A.S., & Smith, J.B. (1993). The effects of high school organization influences the equitable distribution of learning in mathematics and science. *Sociology of Education,* 70 (2). Washington, DC: The American Sociological Association.

Martin, M., Blank, R., & Smithson, J. (1996). *Guide for educators on the use of surveys and data on enacted curriculum.* Washington, DC: CCSSO, State Collaborative on Assessment and Student Standards (SCASS).

McKnight, C.C., Crosswhite, F.J., Dossey, J.A., Kifer, E., Swafford, J.O., Travers, K.J., & Cooney, T.J. (1987). *The underachieving curriculum: Assessing U.S. school mathematics from an international perspective.* Champaign, IL: Stipes Publishing.

Monk, D.H. (1993). *Subject area preparation of secondary mathematics and science teachers and student achievement.* Ithaca, NY: Cornell University, Department of Education.

Mullis, I.V.S., Dossey, J.A., Owen, E.H. & Phillips, G.W. (1993). *NAEP 1992 math report card for the nation & the states.* Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Murnane, R.J., & Raizen, S.A. (Eds.) (1988). *Improving indicators of the quality of science and mathematics education in grades K–12.* Washington, DC: National Research Council, National Academy Press.

National Center for Education Statistics (1995, 1996). *Common core of data.* Washington, DC: U.S. Department of Education.

National Center for Education Statistics (1996). *SASS by state, 1993–94 schools and staffing survey, public school teachers.* Washington, DC: U.S. Department of Education.

National Center for Education Statistics (1996a). *Pursuing excellence: A study of U.S. eighth-grade mathematics and science teaching, learning, curriculum, and achievement in international context. Initial findings from the third international mathematics and science study.* Washington, DC: U.S. Department of Education.

National Center for Education Statistics (1996b). *Schools and staffing in the United States: A statistical profile, 1993–94.* Washington, DC: U.S. Department of Education.

National Center for Education Statistics (1997). *Data compendium for the NAEP 1996 mathematics assessment.* Washington, DC: U.S. Department of Education.

National Center for Education Statistics (1997a). *Pursuing excellence: A study of U.S. fourth-grade mathematics and science teaching, learning, curriculum, and achievement in international context. Initial findings from the third international mathematics*

and science study. Washington, DC: U.S. Department of Education.

National Center for Education Statistics (1997b). *The condition of education 1997.* Washington, DC: U.S. Department of Education.

National Commission on Excellence in Education (1983). *A nation at risk: The imperative for educational reform.* Washington, DC: U.S. Department of Education.

National Council of Teachers of Mathematics (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics (1991). *Professional standards for teaching mathematics.* Reston, VA: Author.

National Education Goals Panel (1996). *The national education goals report: Building a nation of learners—1996.* Washington, DC: National Education Goals Panel.

National Governors' Association (1986). *Time for results: The governors' 1991 report on education.* Washington, DC: National Governors' Association, Center for Policy Research and Analysis.

National Research Council (1995). *National science education standards.* Washington, DC: National Academy Press.

National Science Board (1993). *Science and engineering indicators—1993.* Washington, DC: National Science Foundation.

National Science Board Commission on Precollege Education in Mathematics, Science, and Technology (1983). *Educating Americans for the 21st century.* Washington, DC: National Science Foundation.

National Study Panel on Education Indicators (1991). *Education counts: An indicator system to monitor the nation's educational health.* Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Oakes, J. (1986). *Educational indicators: A guide for policymakers.* New Brunswick, NJ: Center for Policy Research in Education.

Oakes, J. (1989). What educational indicators? The case for assessing the school context. *Educational Evaluation and Policy Analysis, 11*(2), pp. 181-199.

Oakes, J. (1990). *Multiplying inequalities: The effects of race, social class, and tracking on opportunities to learn mathematics and science.* Santa Monica, CA: The Rand Corporation.

O'Sullivan, C.Y., Reese, C.M., & Mazzeo, J. (1997). *NAEP 1996 science report card for the nation and the states.* Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Pelavin, S., & Kane, M. (1990). *Changing the odds: Factors measuring access to college.* New York: College Entrance Examination Board.

Porter, A.C. (1991). Creating a system of school process indicators. *Educational Evaluation and Policy Analysis, 13*(1), pp. 13-29.

Porter, A.C., Kirst, M.W., Osthoff, E.J., Smithson, J.L., & Schneider, S.A. (1994). *Reform up close: A classroom analysis.* Madison, WI: Wisconsin Center for Education Research.

Reese, C.M., Miller, K.E., Mazzeo, J., & Dossey, J.A. (1997). *NAEP 1996 mathematics report card for the nation and the states.* Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Rock, D., Braun, H.I., & Rosenbaum, P.R. (1985). *Excellence in high school education: Cross-sectional study, 1980–1982.* (Final Report). Princeton, NJ: Educational Testing Service.

Sebring, P.A. (1987). Consequences of differential amounts of high school coursework: Will the new graduation requirements help? *Education Evaluation and Policy Analysis,* Vol. 9, Number 3.

Shavelson, R., McDonnell, L., Oakes, J., & Carey, N. (1987). *Indicator systems for monitoring mathematics and science education.* Santa Monica, CA: Rand Corporation.

Shavelson, R., McDonnell, L., Oakes, J., & Carey, N. (1989). *Indicators for monitoring mathematics and science education: a sourcebook.* Santa Monica, CA: Rand Corporation.

Walberg, H.J. (1984). Improving the productivity of American schools. *Educational Leadership,* 41(8).

Weiss, I.R. (1994). *A profile of science and mathematics education in the United States: 1993.* Chapel Hill, NC: Horizon Research, Inc.

Westat, Inc. (1994). *The 1994 high school transcript study tabulations.* Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Appendix A. Student Background Data, State Policies, Urban School Indicators

Figure A.1 High School Students Enrolled in General or Consumer Mathematics, Percent of Grades 9–12 Students, 1990 to 1996 92

Appendix A.1 Percent of Public School Students by Race/Ethnicity, by State, 1995–96 93

Appendix A.2 State Course Credit Requirements for High School Graduation, Core Academic Subjects: 1996 94

Appendix A.3 High School Math and Science Enrollments in Major Cities, Percent Taking Courses by Graduation, 1996 95

Appendix A.4 Certification of Mathematics and Science Teachers in Major Cities, Grades 9–12, 1996 96

Appendix A.5 Certification of Grades 7–8 Mathematics and Science Teachers in Major Cities, 1996 97

Appendix A.6 Secondary Teachers: State Requirements for License in English/Language Arts, Mathematics, Science, Social Studies 98

Appendix A.7 Middle Grade Teachers: State Requirements in Academic Fields for Middle Grades License 99

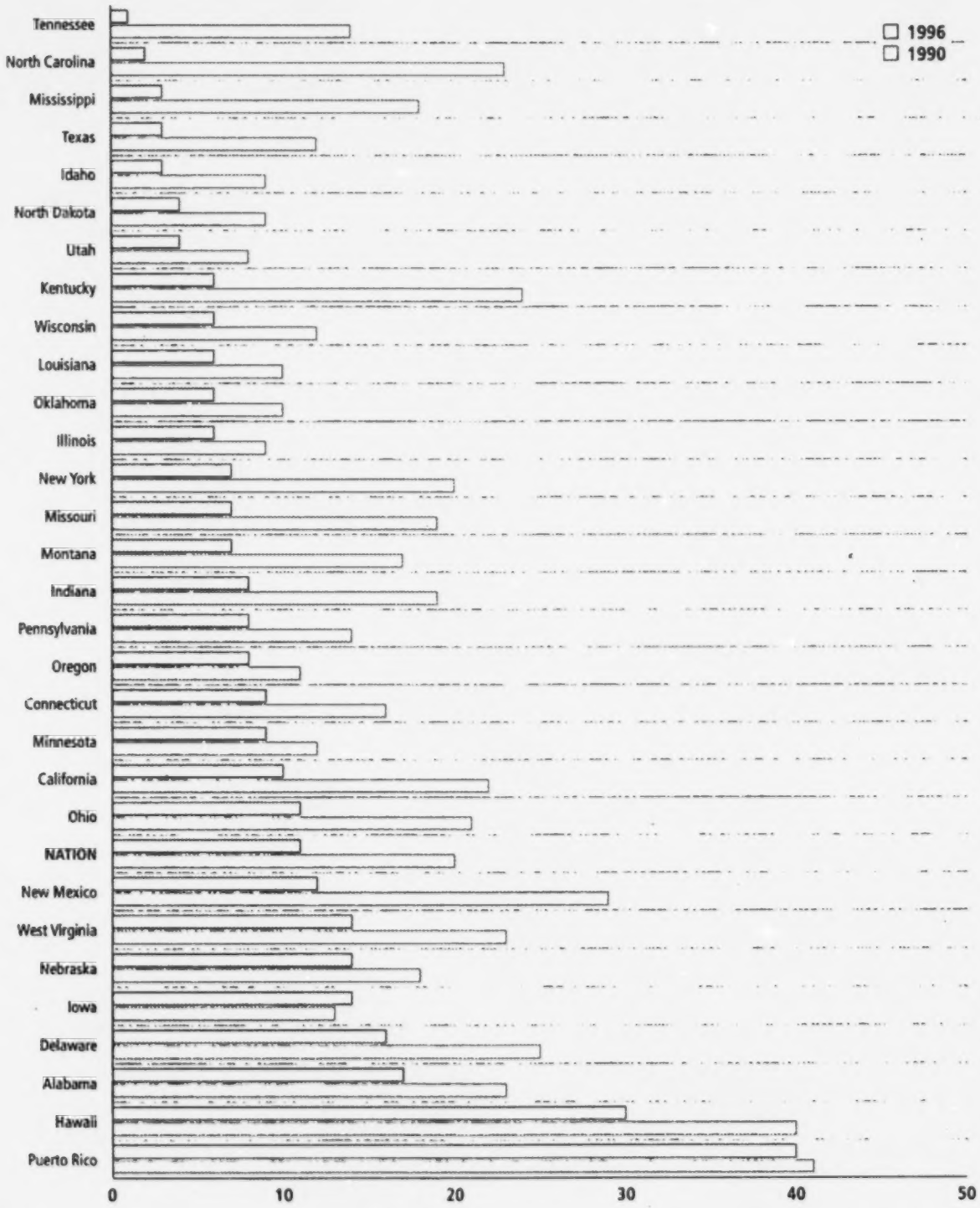
Appendix A.8 Elementary Teachers: State Requirements in Academic Fields for Elementary License 100

Appendix A.9 Number of Public Elementary, Middle and High Schools, 1995–96 101

Appendix A.10 Average Class Size in Mathematics and Science and Percent Classes Over 30 Students, Grades 7–12, 1993–94 102

Appendix A.11 Standard Errors for Table 23, Mathematics and Science Teachers with Major in Assigned Field, Grades 7–12, 1994 103

Figure A.1 High School Students Enrolled in General or Consumer Mathematics, Percent of Grades 9–12 Students, 1990 to 1996



Source: State Departments of Education, Data on Public Schools, 1995–96.
Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997

Appendix A.1 Percent of Public School Students by Race/Ethnicity, by State, 1995–96

STATE	% White	% Black	% Hispanic	% Asian	% American Indian
Alabama	62.1	36.0	.5	.6	.7
Alaska	63.7	1.6	2.7	4.4	24.5
Arizona	56.4	4.3	30.2	1.8	7.3
Arkansas	73.6	23.8	1.5	.7	.4
California	40.4	8.7	38.7	11.2	.9
Colorado	72.5	5.4	18.4	2.5	1.1
Connecticut	72.2	13.4	11.8	2.4	.2
Delaware	64.7	29.4	4.0	1.7	.2
Dist. of Columbia	4.0	87.5	7.0	1.4	*
Florida	57.5	25.3	15.3	1.8	.2
Georgia	58.2	37.9	2.2	1.6	.1
Hawaii	22.9	2.6	4.9	69.3	.4
Idaho	n/a	n/a	n/a	n/a	n/a
Illinois	63.7	21.0	12.1	3.0	.2
Indiana	85.6	11.1	2.3	.8	.2
Iowa	92.7	3.3	2.1	1.5	.4
Kansas	82.4	8.5	6.1	1.9	1.1
Kentucky	89.1	9.8	.4	.6	*
Louisiana	51.0	46.0	1.1	1.3	.5
Maine	97.3	.8	.4	.9	.6
Maryland	57.5	35.0	3.3	3.8	.3
Massachusetts	78.5	8.2	9.3	3.8	.2
Michigan	76.4	18.3	2.7	1.5	1.0
Minnesota	87.4	4.8	2.0	3.9	1.9
Mississippi	47.7	51.0	.3	.6	.4
Missouri	81.7	16.0	1.0	1.0	.2
Montana	87.5	.5	1.4	.8	9.8
Nebraska	87.1	5.9	4.4	1.3	1.4
Nevada	66.8	9.5	17.2	4.5	1.9
New Hampshire	96.7	.9	1.2	1.1	.2
New Jersey	62.5	18.5	13.5	5.3	*
New Mexico	39.5	2.4	46.7	1.0	10.4
New York	56.9	20.3	17.4	5.0	.4
North Carolina	64.6	30.7	1.9	1.3	1.5
North Dakota	89.6	.8	1.1	.8	7.7
Ohio	82.2	15.3	1.4	1.0	.1
Oklahoma	69.5	10.4	3.9	1.3	15.0
Oregon	85.2	2.6	6.8	3.4	2.0
Pennsylvania	80.6	14.0	3.5	1.8	*
Rhode Island	78.9	7.0	10.3	3.3	.5
South Carolina	56.7	41.7	.6	.7	.2
South Dakota	83.7	.9	.7	.7	13.9
Tennessee	74.9	23.0	.8	.9	.4
Texas	46.4	14.3	36.7	2.3	.3
Utah	90.3	.7	5.4	2.2	1.4
Vermont	97.3	.7	.4	1.0	.6
Virginia	66.6	26.5	3.2	3.5	.2
Washington	78.3	4.7	7.8	6.4	2.6
West Virginia	95.2	4.0	.3	.4	.1
Wisconsin	83.2	9.4	3.3	2.8	1.3
Wyoming	89.3	1.0	6.1	.8	2.7
American Samoa	–	–	–	100.0	–
Guam	6.7	1.3	.5	91.4	*
Northern Marianas	.7	*	*	99.3	*
Puerto Rico	–	–	100.0	–	–
Trust Territories	58.6	22.2	8.5	9.5	1.0
Virgin Islands	.9	84.6	14.1	.4	*
United States	63.7	16.7	14.7	3.8	1.1

Note: * Less than 0.1 percent

Source: NCES, 1995–96 Common Core of Data.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Appendix A.2 State Course Credit Requirements for High School Graduation, Core Academic Subjects: 1996

STATE	CREDITS FOR REGULAR DIPLOMA: Math	Science	English	Social Studies	TOTAL (Core + Electives)	Exit Test Required
Alabama	**4**	**4**	4	**4**	21.5	x
Alaska	2	2	4	3	21	
American Samoa	3	3	4	4	17	
Arizona (1994 data)	2	2	4	2.5	20	
Arkansas	3	3	4	3	19	
California	2	2	3	3	12	
Colorado	L	L	L	L	—	
Connecticut	3	2	4	3	20	
Delaware	3	3	4	3	19	
Dist. of Columbia	3	3	4	3.5	18	
DoDEA	2/3	3/2	4	3	18	
Florida (1994 data)	3	3	4	3	22	x
Georgia	3	3	4	3	19	x
Hawaii	**3**	**3**	4	4	20	x
Idaho	2	2	4	2	16	
Illinois	2	1	3	2	10.25	
Indiana	2	2	4	2	18	
Iowa	L	L	L	1.5	1.5	
Kansas	2	2	4	3	20	
Kentucky	3	2	4	2	19	
Louisiana (1994 data)	3	3	4	3	20.5	x
Maine	2	2	4	2	13.5	
Maryland	3	3	4	3	18	x
Massachusetts	L	L	L	1	1	
Michigan	L	L	4	0.5	4.5	
Minnesota	1	1	4	3	18.5	
Mississippi	3	2	4	**3**	20	x
Missouri	2	2	3	2	19	
Montana	2	2	4	**2**	17	
Nebraska	L	L	L	L	LB	
Nevada	2	2	4	2	18.5	x
New Hampshire	2	2	4	2.5	14.5	
New Jersey	3	2	4	3	16	x
New Mexico	3	2	4	3	21	x
New York	2	2	4	4	12	x
North Carolina	**2**	**2**	4	2	19	x
North Dakota	2	2	4	3	16	
Ohio	2	1	3	2	17	x
Oklahoma	2	2	4	2	20	
Oregon	2	2	3	3.5	18.5	
Pennsylvania	3	3	4	3	18	
Puerto Rico	3	1	3	3	13	
Rhode Island	2	2	4	2	16	
South Carolina	3	2	4	3	20	x
South Dakota	2	2	4	3	19	
Tennessee (1994 data)	3	3	4	1	22	x
Texas	3	2	4	2.5	18.5	x
Utah	2	2	3	3	19.5	
Vermont	—	5 combined	—	4	3	12
Virginia	—	5 combined	—	4	3	21
Virgin Islands	2	2	4	2	16	
Washington	2	2	3	2.5	15	
West Virginia	2	2	4	3	18	
Wisconsin	2	2	4	3	11	
Wyoming	L	L	L	1	1	
TOTAL	2.5–4 credits: 20 states	2.5–4 credits: 12 states	4 credits: 42 states	3–4 credits: 31 states		17 States

Notes: Algebra 1 required by Georgia, Louisiana, Mississippi, North Carolina, Texas; Arkansas requires Algebra 1 or Applied Math 1.

Bold face type = change of requirement since 1993; L = 6 states (local board sets requirements)

Source: State Departments of Education, CCSSO Policies and Practices Survey, Spring, 1996.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

104

Appendix A.3 High School Math and Science Enrollments in Major Cities, Percent Taking Courses by Graduation, 1996

STATE/DISTRICT	Algebra 1/ Integrated Math 1	Geometry/ Integrated Math 2	Algebra 2/ Integrated Math 3	Trigonometry/ Pre-Calculus	Calculus	Biology 1st Year	Chemistry 1st Year	Physics 1st Year
California	95+	57	49	25	10	79	39	18
Fresno	88	52	37	21	10	71	39	22
Los Angeles	89	53	48	24	10	95+	41	13
San Diego	59	23	18	24	5	21	21	13
Illinois	83	79	73	44	12	95+	63	33
Chicago	90	95+	49	23	7	95+	59	38
Indiana	91	67	58	34	16	95+	57	24
Indianapolis	94	46	43	18	9	91	49	14
Louisiana	95+	88	64	29	6	95+	54	25
New Orleans	95+	95+	71	31	6	95+	88	37
Massachusetts	95+	75	70	47	17	95+	67	37
Boston	95+	70	62	41	8	93	47	20
Missouri	95+	71	76	32	13	95+	51	18
St. Louis	95+	55	27	23	7	85	78	28
New York	95+	68	52	31	14	95+	64	32
New York City	95+	56	36	18	14	95+	54	28
Ohio	95+	74	63	38	12	95+	58	23
Cincinnati	95+	65	75	33	19	95+	95+	30
Cleveland	95+	63	94	81	4	95+	43	14
Columbus	89	69	67	21	6	63	51	23
Pennsylvania	95+	70	68	61	18	95+	67	39
Philadelphia	95+	66	53	28	8	95+	66	37
Tennessee	95+	69	65	23	6	92	52	13
Memphis	95+	74	63	32	5	95+	58	14
Texas	95+	73	72	39	9	95+	55	18
Dallas	95+	95+	95+	26	9	95+	63	15
El Paso	95+	85	81	27	8	86	58	10
Houston	95+	82	79	35	9	95+	46	14
San Antonio	95+	60	58	27	5	95+	55	10
Wisconsin	95+	95+	68	46	15	95+	76	35
Milwaukee	95+	95+	26	16	21	95+	95+	45

Note: Chicago and Illinois: 1994–95 data.

Source: State Departments of Education, Data on Public Schools, 1995–96.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Appendix A.4 Certification of Mathematics and Science Teachers in Major Cities, Grades 9–12, 1996

	PERCENT CERTIFIED				
STATE/DISTRICT	Math	Biology	Chemistry	Physics	Earth Science
California	80	82	82	84	66
Fresno	62	65	67	100	—
Los Angeles	74	76	83	79	58
San Diego	—	—	—	—	—
Illinois	95	88	94	94	93
Chicago	90	88	90	92	77
Indiana	97	96	96	86	74
Indianapolis	92	94	100	100	79
Louisiana	88	83	83	68	48
New Orleans	82	74	78	50	100
Massachusetts	91	92	96	96	89
Boston	51	50	75	81	56
Missouri	95	94	94	85	72
St. Louis	93	95	100	100	89
New York	93	89	91	85	78
New York City	91	79	84	83	79
Ohio	96	89	93	92	72
Cincinnati	96	67	74	85	8
Cleveland	93	64	90	93	—
Columbus	96	97	100	95	83
Pennsylvania	91	96	95	95	95
Philadelphia	97	100	100	100	100
Tennessee	90	92	93	83	88
Memphis	90	90	88	88	90
Texas	81	74	87	77	53
Dallas	73	61	83	78	37
El Paso	71	86	89	100	26
Houston	76	46	86	47	21
San Antonio	74	85	92	100	83
Wisconsin	100	100	100	100	100
Milwaukee	100	100	100	100	100

Notes: — Data not available.
Certified = Teachers assigned one or more period to subject who have state certification in subject.
Science Certified = Specific-field or broad-field certification.
Pennsylvania and Philadelphia = Grades 7–12.

Source: State Departments of Education, Data on Public Schools, 1995–96.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Appendix A.5 Certification of Grades 7–8 Mathematics and Science Teachers in Major Cities, 1996

STATE/DISTRICT	MATHEMATICS GRADES 7–8			SCIENCE GRADES 7–8		
	% Certified Math	% Certified Elementary	% Not Certified	% Certified Science	% Certified Elementary	% Not Certified
California	51	36	13	44	42	14
Fresno	60	15	24	48	28	24
Los Angeles	61	24	15	58	25	17
San Diego	—	—	—	—	—	—
Illinois	0	97	3	0	95	5
Chicago	0	100	0	—	—	—
Indiana	90	8	2	92	5	3
Indianapolis	71	16	14	73	15	13
Louisiana	85	0	15	74	0	26
New Orleans	73	0	27	61	0	39
Massachusetts	62	30	8	68	27	5
Boston	22	44	33	36	18	46
Missouri	82	0	18	76	0	24
St. Louis	41	0	59	43	0	57
New York	91	0	9	85	0	15
New York City	85	0	15	77	0	23
Ohio	—	—	—	—	—	—
Cincinnati	—	—	—	—	—	—
Cleveland	—	—	—	—	—	—
Columbus	—	—	—	—	—	—
Pennsylvania	—	—	—	—	—	—
Philadelphia	—	—	—	—	—	—
Tennessee	96	0	4	93	0	7
Memphis	93	0	7	88	0	12
Texas	63	0	37	60	0	40
Dallas	53	0	47	49	0	51
El Paso	33	0	67	27	0	73
Houston	42	0	58	31	0	69
San Antonio	70	0	30	72	0	28
Wisconsin	—	—	—	—	—	—
Milwaukee	—	—	—	—	—	—

Notes: — Data not available.

Certified math (science) = Teachers assigned one or more period to subject who have state certification in secondary math (science) or middle level math (science).

Certified Elementary = Certification in Elementary Education, General Secondary/Middle, or science (math).

Texas: not certified includes elem./middle.

Source: State Departments of Education, Data on Public Schools, 1995-96.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Appendix A.6 Secondary Teachers: State Requirements for License in English/Language Arts, Mathematics, Science, Social Studies

STATE	COURSE CREDITS IN FIELD						
	English/ L. Arts	Math	Broad Field Science	Biology Chemistry Physics Earth Sci.	Social Studies	History Economics Civics Geography	Methods of Teaching in Field E/LA,M,S,SSt
Alabama	27-39	39	60	27	60	27	—
Alaska	Approved Teacher Ed. Program						Yes
Arizona (1994)	18	30	30	30			—
Arkansas	21	21	—	24	—	33	—
California	45	45	—	45	—	45	—
Colorado	Major/Approved Teacher Ed. Program						Yes
Connecticut	30	30	—	30	Major	18 H	Yes
Delaware	36	36	—	42 (b,es) 45 (c,p)	48	—	Yes
Dist. of Columbia	36	33	—	30	33	—	—
DoDEA	24	24	24	24	24	—	E/LA
Florida (1994)	30	30	—	21			—
Georgia	Major required						Yes
Hawaii	Major required						Yes
Idaho	20	20	20	20	—	20	Yes
Illinois	32	32	32	32	—	32	Yes
Indiana	36	36	—	51	52	—	Yes
Iowa	24	24	24	24	24	15	Yes
Kansas	Standards-based						—
Kentucky	24–48	21–30	48	21–30	—	21–27	—
Louisiana (1994)	27	20	—	20			—
Maine	36	36	—	36 (life, phy.)	18	—	—
Maryland	36	36	—	36	36	26-36	—
Massachusetts	36	36	36	36	—	24/major	Yes
Michigan	36/24	30/20	36/24	30/20	36/24	—	Reading
Minnesota	Major and Approved Program						Yes
Mississippi	Major and Approved Program						—
Missouri	30	30	30	20	40	—	—
Montana	30/20	30/20	40	30/20	40	30/20	Yes
Nebraska	30	30	59	24	60	36	—
Nevada	36	30/16	36/24	30/16			Yes
New Hampshire	Major required						—
New Jersey (1994)	30	30	—	30			—
New Mexico	24	24	24	—	24	—	—
New York	36	36	—	36/18	36	—	—
North Carolina	Approved Teacher Ed. Program						—
North Dakota	Major or minor						Yes
Ohio	60	30	60	30	60	30	Yes
Oklahoma	40	40	—	40	40	—	Yes
Oregon	45	42	45	45 (b,es) 27 (c,p)	54	—	Yes
Pennsylvania	Approved Teacher Ed. Program						Yes
Puerto Rico	—	—	—	—	—	—	Yes
Rhode Island	30	30	30	30	30	6	—
South Carolina (1994)	30	30	30	30/12			—
South Dakota	21	18	21	12 (b,c,p) 18 (es)	24	6	—
Tennessee (1994)	36 qtr.	36 qtr.	48 qtr.	24 qtr.			—
Texas	24	24	48	24	22	24	—
Utah	45 qtr.	45 qtr.	—	69 (b,es) 45 (c,p) qtr.	69	45	Yes
Vermont	Competency-based program						—
Virginia	36	36	—	32 (b,c,p) 36 (es)	42	36	—
Virgin Islands	36	36	36	36	36	36	—
Washington	45/24 qtr.	24 qtr.	45 qtr.	24 qtr.	45	24	Yes
West Virginia	Job-related objectives						—
Wisconsin	34	34	54	34	54	34	Yes
Wyoming	Major required						Yes
TOTAL	**39**	**39**	**24**	**38**	**26**	**21**	**26**

Notes: "—" No state requirement. 30/20 = major or minor. "Credits" = semester credits, unless quarter credits specified. States also require professional education credits.

Source: State Departments of Education, CCSSO Policies and Practices Survey, February, 1996.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC.

Appendix A.7 Middle Grade Teachers: State Requirements in Academic Fields for Middle Grades License

STATE	Middle Grades Certification	COURSE CREDITS IN FIELD: English Lang. Arts	Math	Science	Social Studies	Methods of Teaching in Field E/LA,M,S,SSt
Alabama	4–8		27-39 cr. in 1 field			—
Alaska	6–9		Approved Teacher Ed. program			Yes
Arizona (1994 data)		—	—	—		—
Arkansas	5–8		18 cr. in 1 field			—
California	—	—	—	—	—	—
Colorado	5–9		Major / Approved Teacher Ed. Program			—
Connecticut	4–8		39 cr. in 5 of 6 areas & major		3 History	Yes
Delaware	5–8	9	9	12	9	E/LA
Dist. of Columbia	4–8	12	6	6	30	Yes
DODEA	5–8	18	18	18	18	E/LA
Florida (1994 data)		—	—	—		—
Georgia	4–8		Competency-based			Yes
Hawaii	—	—	—	—		—
Idaho	—	—	—	—	—	—
Illinois	5–8		18 cr. in 1 field, 9 in 2nd field			Yes
Indiana	5–9		18 cr. in 1 field		18	Yes
Iowa	5–8	—	—	—	6	—
Kansas	5–9		Standards-Based			—
Kentucky	5–8		24 cr. in 2 fields			Reading
Louisiana (1994 data)	yes	18	12	16		—
Maine	5–8	6	6	6	—	—
Maryland	7–8	—	—	—	—	—
Massachusetts	5–9		Major in 1 field			Yes
Michigan	yes	36/24	30/20	36/24	2	Reading
Minnesota	5–9		Approved Program and Elem. or Sec. License			—
Mississippi	4–8		18 credits in 2 fields			App. Prog.
Missouri	4–8		Major		2	Yes
Montana	—	—	—	—	—	—
Nebraska	4–9		Approved Program		18	Yes
Nevada	—	—	—	—		—
New Hampshire	yes		Major			—
New Jersey (1994 data)	—	—	—	—		—
New Mexico	—	—	—	—		—
New York	—	—	—	—		—
North Carolina	6–9		Approved Program		18 SSt, H	—
North Dakota	5–8		Major or Minor			Yes
Ohio	5–9	30	20	20	20	Yes
Oklahoma	7–8		18 cr. in 1 field			—
Oregon	—	—	—	—	—	—
Pennsylvania	—	—	—	—	—	—
Puerto Rico	—	—	—	—	—	—
Rhode Island	5–6, 7–8		8 cr. in 1 field			Yes
South Carolina (1994 Data)	yes	12	—	12	—	—
South Dakota	5–8	15	12	12	12	—
Tennessee (1994 Data)	—	—	—	—		
Texas	—	—	—	—		—
Utah	—	—	—	—		—
Vermont	5–8	—	—	—	Comp.-based	—
Virgin Islands	—	—	—	—	—	—
Washington	—	—	—	—	—	—
West Virginia	5–8		Job-related objectives			—
Wisconsin	5–9		22 cr. in 1 field			—
Wyoming	5–9		Approved Teacher Ed. Program			—
TOTAL	**34**					**17**

Notes: "—" No state course credit requirement. "Credits" = semester credits, unless quarter credits specified. States also require professional education credits.

Source: State Departments of Education, CCSSO Policies and Practices Survey, February, 1996.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC.

Appendix A.8 Elementary Teachers: State Requirements in Academic Fields for Elementary License

STATE	COURSE CREDITS IN FIELD: English Lang. Arts	Math	Science	Social Studies	Methods of Teaching Required E/La, M, S, SSt	Elementary License Grades
Alabama	15	9	12	12	No	1–6
Alaska		Approved Teacher Ed. Program			All	K–8
Arizona (1994)	6	6	8			
Arkansas	12	9	9		M, S	1–6
California		84 credits in 10 areas, standards-based			—	K–12
Colorado		Major and Approved Program			All	K–6
Connecticut		39 cr. in 5 of 6 areas and Major		3	E/LA	K–6
Delaware	9	9	12	9	All	K–4, 5–8
Dist. of Columbia	12	12	12	12	All	1–6
DODEA	—	—	—	—	E/LA, M, S	1–8
Florida (1994)	—	—	—			
Georgia		Approved Teacher Ed. Program			All	P–8
Hawaii	—	—	—	—	—	K–6
Idaho	12	6	8	—	All	K–8
Illinois	12	6	12	12	All	K–9
Indiana	9	6	6	6	—	1–6, 7/8
Iowa		12 cr. in 1 field /interdis.			All	K–6
Kansas		Standards-based			—	K–9
Kentucky	12	6	6	12	E/LA, M, S	K–4
Louisiana (1994)	12	6	12			
Maine	6	6	6	6	All	K–8
Maryland	9	12	12	9	—	1–6, middle school
Massachusetts		Major in 1 field			All	1–6
Michigan		Major or minor			Reading	K–5 / 8
Minnesota		Approved Program			All	1–6
Mississippi	12	9	9	12	App. Prog.	K–4
Missouri		Approved Program/Standards		2	All	1–8
Montana		Approved Program/Standards			—	K–8
Nebraska		Approved Program			All	K–8
Nevada		Elementary Ed. degree			All	
New Hampshire		Approved Program / Major			—	K–8
New Jersey (1994)		30 cr. in 1 field				
New Mexico		24 cr. in 1 field		—	E/LA, M	
New York	6	6	6	6	E/LA	
North Carolina		Approved Program			—	
North Dakota	—	—	—	—	All	1–8
Ohio		30 credits in 1 field		30	All	1–8
Oklahoma	6	6	3	3	All	1–8
Oregon	18 qtr.	12 qtr.	9 qtr.	9	All	PP–9
Pennsylvania		Approved Teacher Ed. Program			All	K–6
Puerto Rico		Not reported			All	K–6
Rhode Island		Approved Program			All	1–6
South Carolina (1994)	—	—	—	—		
South Dakota	7	6	4	7	All	K–8
Tennessee (1994)	12	6	12	—	—	
Texas		18-24 cr. in 1 field			All	K–8
Utah	—	6 qtr.	3 qtr.		All	1–8
Vermont		Competency-based Program				K–6
Virginia	6	6	6	yes	—	K–3, 3–6
Virgin Islands		36 credits in 1 field			—	K–6
Washington		Individual program requirements			All	K–8
West Virginia		Job-related objectives				K–8
Wisconsin	—	12	12	12	No	PK–3, 1–6
Wyoming		Approved Teacher Ed. Program			All	K–8
TOTAL	**19**	**22**	**21**	**17**	**33**	**44**

Notes: "Credits" = semester credits, unless quarter credits specified. States also require professional education credits.

Source: State Departments of Education, CCSSO Policies and Practices Survey, February, 1996.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC.

110

Appendix A.9 Number of Public Elementary, Middle, and High Schools, 1995–96

STATE	Elementary	Middle	High	Combined Elem./Sec.	Other (non-graded)
Alabama	674	222	253	153	13
Alaska	167	33	67	208	4
Arizona	704	179	170	15	10
Arkansas	579	173	321	6	16
California	5,025	1,161	1,373	172	144
Colorado	838	253	288	20	19
Connecticut	616	177	156	26	1
Delaware	88	42	32	19	0
Dist. of Columbia	117	27	23	2	16
Florida	1,546	414	360	324	42
Georgia	1,095	315	281	68	4
Hawaii	169	28	31	15	3
Idaho	329	101	150	18	12
Illinois	2,572	708	642	32	171
Indiana	1,175	302	347	33	6
Iowa	851	294	370	28	8
Kansas	871	246	356	7	5
Kentucky	810	233	281	2	42
Louisiana	794	279	251	114	32
Maine	449	122	107	14	4
Maryland	845	223	179	17	12
Massachusetts	1,208	299	290	25	9
Michigan	2,051	579	638	88	99
Minnesota	1,026	257	561	84	29
Mississippi	444	170	175	74	25
Missouri	1,169	338	495	30	40
Montana	483	233	175	0	2
Nebraska	951	100	313	25	1
Nevada	268	60	75	9	7
New Hampshire	288	94	74	4	0
New Jersey	1,449	390	306	70	126
New Mexico	427	150	128	3	12
New York	2,441	683	735	126	163
North Carolina	1,186	411	325	38	15
North Dakota	332	39	195	4	3
Ohio	2,190	680	691	124	19
Oklahoma	994	343	463	0	21
Oregon	751	205	206	46	8
Pennsylvania	1,946	526	595	21	25
Rhode Island	210	53	42	2	2
South Carolina	586	244	198	11	13
South Dakota	421	194	185	2	16
Tennessee	952	239	253	52	19
Texas	3,461	1,373	1,276	386	142
Utah	428	119	138	9	31
Vermont	253	24	49	17	19
Virginia	1,110	315	294	18	44
Washington	1,122	324	388	95	20
West Virginia	540	137	124	23	18
Wisconsin	1,228	351	426	29	3
Wyoming	237	88	75	0	1
American Samoa	23	1	6	0	1
Guam	23	6	5	0	0
Northern Mariana	20	1	3	0	0
Puerto Rico	929	221	168	181	48
Dept. of Defense	—	—	—	—	—
Virgin Islands	23	5	4	1	0

Note: — Data not available.

Source: NCES, Common Core of Data surveys, 1995–96.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Appendix A.10 Average Class Size in Mathematics and Science and Percent Classes Over 30 Students, Grades 7–12, 1993–94

STATE	All Math Average Class	% All Classes Over 30	Advanced Math Average Class	% Advanced Over 30	All Science Average Class	% All Classes Over 30	Biology Average Class	% Biology Over 30
Alabama	22	14	22	20	24	17	24	22
Alaska	20	15	19	—	21	16	22	—
Arizona	27	37	23	16	27	43	27	44
Arkansas	18	3	19	0	20	5	21	9
California	28	53	28	48	29	59	29	54
Colorado	24	21	21	23	24	16	26	32
Connecticut	19	3	23	—	19	2	20	—
Delaware	23	—	—	—	28	—	—	—
Dist. of Columbia	20	—	—	—	—	—	—	—
Florida	25	35	24	—	28	58	27	48
Georgia	24	22	24	—	24	15	24	23
Hawaii	22	29	—	—	24	—	23	—
Idaho	23	17	19	12	24	19	25	25
Illinois	24	16	25	—	24	19	24	14
Indiana	22	11	22	14	23	16	24	13
Iowa	18	8	17	—	22	9	23	22
Kansas	20	8	21	—	22	16	22	13
Kentucky	22	12	23	—	24	22	26	41
Louisiana	21	11	19	13	24	27	25	20
Maine	19	4	18	3	20	2	19	—
Maryland	25	33	24	—	25	36	23	13
Massachusetts	22	8	20	9	22	17	21	11
Michigan	25	20	24	—	25	22	24	17
Minnesota	25	21	23	23	26	23	28	46
Mississippi	22	12	22	—	23	21	23	13
Missouri	23	13	20	7	23	16	25	—
Montana	18	7	17	1	19	6	22	10
Nebraska	19	6	19	—	19	10	17	2
Nevada	27	38	24	—	27	—	26	—
New Hampshire	21	7	21	—	23	—	22	0
New Jersey	20	5	18	—	20	2	21	—
New Mexico	23	23	23	—	24	22	25	26
New York	22	22	21	17	24	24	23	19
North Carolina	23	10	23	—	23	5	23	8
North Dakota	20	6	18	3	21	5	20	2
Ohio	22	13	23	—	23	12	24	21
Oklahoma	19	5	16	2	19	6	22	14
Oregon	23	19	22	28	25	20	26	26
Pennsylvania	25	23	23	—	23	18	24	—
Rhode Island	22	—	—	—	21	—	24	—
South Carolina	22	11	17	—	23	13	23	12
South Dakota	18	5	18	3	21	11	22	18
Tennessee	25	29	23	—	27	34	26	28
Texas	21	12	21	14	22	15	23	14
Utah	28	52	27	—	29	54	29	56
Vermont	20	—	—	—	20	—	20	0
Virginia	20	6	20	—	22	2	23	11
Washington	25	24	26	36	25	26	26	31
West Virginia	21	12	22	—	23	21	22	12
Wisconsin	23	15	22	—	23	11	24	13
Wyoming	19	4	18	—	18	3	22	—
NATION	**23**	**19**	**22**	**18**	**24**	**22**	**24**	**20**

Notes: — Respondents too few for a reliable state estimate; see NCES (1996) for standard errors.

Source: NCES, Schools and Staffing Survey, 1993–94.

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Appendix A.11 Standard Errors for Table 23, Mathematics and Science Teachers with Major in Assigned Field, Grades 7–12, 1994

	MAIN ASSIGNMENT		MAIN OR SECOND ASSIGNMENT	
STATE	Math % with Major in Math	Science % with Major in Science	Math % with Major or Minor	Science % with Major or Minor
Alabama	2.5	4.4	3.9	4.7
Alaska	6.1	5.3	4.5	4.7
Arizona	5.1	5.4	7.2	4.3
Arkansas	5.0	5.3	4.2	5.4
California	5.0	6.6	4.7	6.1
Colorado	5.7	5.8	5.5	3.5
Connecticut	4.2	2.9	2.9	2.0
Delaware	—	9.3	—	10.5
Dist. of Columbia	9.7	—	9.7	—
Florida	5.1	7.6	3.4	8.4
Georgia	5.9	5.7	5.2	5.5
Hawaii	13.0	10.2	10.4	8.6
Idaho	3.9	4.9	4.3	3.0
Illinois	3.3	4.7	3.4	2.7
Indiana	3.3	4.4	1.8	3.3
Iowa	6.0	5.0	3.2	4.9
Kansas	5.4	4.4	4.0	3.4
Kentucky	4.9	9.0	5.6	8.8
Louisiana	4.3	5.5	4.5	5.3
Maine	5.9	7.3	5.0	6.2
Maryland	6.2	4.6	4.0	4.9
Massachusetts	3.0	1.7	3.0	1.7
Michigan	6.4	6.5	6.5	6.2
Minnesota	2.6	1.5	2.4	2.2
Mississippi	5.3	4.3	4.4	3.8
Missouri	2.7	7.5	2.1	6.4
Montana	2.4	3.2	1.9	3.2
Nebraska	4.9	5.1	3.5	5.1
Nevada	8.2	6.3	6.2	7.3
New Hampshire	5.4	5.6	3.8	5.7
New Jersey	6.2	8.1	6.5	6.7
New Mexico	5.3	6.7	3.2	4.7
New York	2.4	2.4	2.2	2.3
North Carolina	6.4	6.0	5.5	5.6
North Dakota	3.1	3.0	2.6	2.7
Ohio	6.1	6.0	4.6	5.5
Oklahoma	3.1	4.1	2.0	3.5
Oregon	6.5	3.2	5.2	3.0
Pennsylvania	1.3	4.4	1.2	4.1
Rhode Island	6.3	5.5	5.8	5.7
South Carolina	5.4	6.3	6.2	5.5
South Dakota	4.1	6.6	2.6	5.2
Tennessee	5.3	6.8	5.1	6.5
Texas	6.0	6.2	2.7	4.9
Utah	3.2	4.6	3.2	4.3
Vermont	6.5	7.2	6.6	7.7
Virginia	7.2	8.7	6.9	8.1
Washington	5.7	3.6	5.2	3.6
West Virginia	4.5	4.9	3.3	4.2
Wisconsin	6.9	10.4	6.4	9.7
Wyoming	3.1	4.2	2.4	3.3
NATION	**0.9**	**1.3**	**0.8**	**1.0**

Note: — Respondents too few for a reliable state estimate.

Source: NCES, Schools and Staffing Survey, 1993–94:

Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1997.

Appendix B. NAEP Sample Questions

Figure B.1 NAEP 1996 Mathematics Sample Questions for Grade 4 106

Figure B.2 NAEP 1996 Mathematics Sample Questions for Grade 8 107

Figure B.3 NAEP 1996 Science Sample Questions for Grade 8 109

Figure B.4 Map of Selected Questions on the NAEP Science Scale for Grade 8 113

Figure B.1 NAEP 1996 Mathematics Sample Questions for Grade 4

N stands for the number of stamps John had. He gave 12 stamps to his sister. Which expression tells how many stamps John has now.?

(A) N + 12

(B) N - 12

(C) 12 - N

(D) 12 x N

Algebra and Functions

Overall Correct	67%
Basic	73%
Proficient	90%

Ms. Hernandez formed teams of 8 students each from the 34 students in her class. She formed as many teams as possible, and the students left over were substitutes. How many students were substitutes?

Answer: _____

Number Sense, Properties, and Operations

Overall Correct	39%
Basic	42%
Proficient	86%

Sam can purchase his lunch at school. Each day he wants to have juice that costs 50¢, a sandwich that costs 90¢, and fruit that costs 35¢. His mother has only $1.00 bills. What is the least number of $1.00 bills that his mother should give him so he will have enough money to buy lunch for five days.

Number Sense, Properties, and Operations

Overall Satisfactory	17%
Basic	14%
Proficient	44%

Figure B.2 NAEP 1996 Mathematics Sample Questions for Grade 8

A car odometer registered 41,256.9 miles when a highway sign warned of a detour 1,200 feet ahead. What will the odometer read when the car reaches the detour?

(A) 42,456.9

(B) 41,279.9

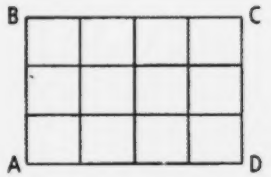
(C) 41,261.3

(D) 41,259.2

(E) 41,257.1

The Measurement Strand

Overall Correct	26%
Basic	25%
Proficient	50%



In the figure above, what fraction of rectangle ABCD is shaded?

(A) $\frac{1}{6}$

(B) $\frac{1}{5}$

(C) $\frac{1}{4}$

(D) $\frac{1}{3}$

(E) $\frac{1}{2}$

Number Sense, Properties, and Operations

Overall Correct	65%
Basic	78%
Proficient	96%

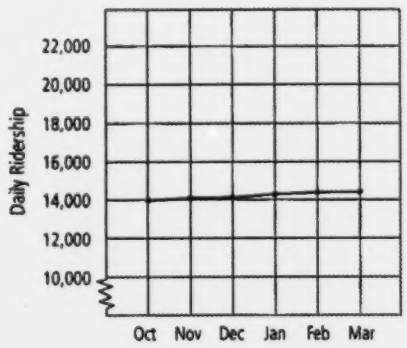
This question requires you to show your work and explain your reasoning. You may use drawings, words, and numbers in your explanation. Your answer should be clear enough so that another person could read it and understand your thinking. It is important that you show all of your work.

Metro Rail Company

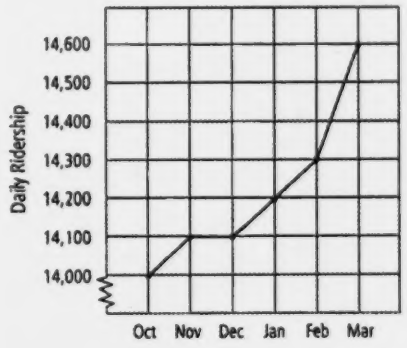
Month	Daily Ridership
October	14,000
November	14,100
December	14,100
January	14,200
February	14,300
March	14,600

The data in the table above has been correctly represented by both graphs shown below.

Graph A



Graph B



Which graph would be best to help convince others that the Metro Rail Company made a lot more money from ticket sales in March than in October?

Explain your reason for making this selection.

Why might people who thought that there was little difference between October and March ticket sales consider the graph you chose to be misleading?

Data Analysis, Statistics, and Probability

Overall Satisfactory or Higher	20%
Basic	22%
Proficient	35%

117

Figure B.3 NAEP 1996 Science Sample Questions for Grade 8

A group of students took potato salad made with mayonnaise to a picnic on a very hot day. Explain how eating the potato salad could cause food poisoning.

Describe something that could be done to the potato salad to prevent the people who eat it from getting food poisoning.

This short constructed-response question measures Life Science and Practical Reasoning. Students' responses were scored using a three-level scoring guide that allowed for partial credit. The sample student response received the highest score, **Complete**. To receive a score of **Complete**, a student's response needed to explain the cause of food poisoning and describe a method of preventing it.

Percentages of Eighth Graders Receiving Complete and Partial Scores

Complete	10%
Partial	61%

Imagine that you could put popcorn kernels into an airtight popcorn popper and measure the mass of the popper with the kernels. After the popcorn has popped, the mass of the popper and the popcorn will be

(A) less than the original mass because popped corn is less dense that the kernels are

(B) equal to the original mass because the container is airtight

(C) greater than the original mass because the volume of the popped corn is greater than that of the kernels

(D) impossible to determine accurately without weighing each piece of popcorn immediately

This multiple-choice question measures Physical Science and Conceptual Understanding and was scored as either correct or incorrect.

The correct answer is B.

Percentage of Eighth Graders Answering Correctly

26%

Figure B.3 NAEP 1996 Science Sample Questions for Grade 8 (continued)

The question refers to an experiment your teacher asks you to perform to compare the heating rate of soil with that of water. To do this, you are given the following materials: two heat lamps, two bins, two thermometers, one sample of soil, one sample of water, and one timer.

You are instructed to heat a sample of soil and a sample of water with heat lamps, measuring the temperature of each sample once a minute for eight minutes.

Suppose that the experiment yielded the results shown in the table below.

Time (min)	0	1	2	3	4	5	6	7	8
Soil temp (°C)	20.0	21.0	22.5	24.0	26.0	27.5	29.5	30.5	32.0
Water temp (°C)	20.0	21.5	27.0	27.5	24.0	25.5	26.0	27.5	28.5

At a beach that has white sand, you measure the temperature of the sand and the temperature of the seawater at 9:00 a.m. You find that both have a temperature of 16°C. If it is clear and sunny all morning, what do the data from the experiment predict about the temperature of the white sand compared to the temperature of the seawater at noon?

_____

Explain your answer.

_____

_____

_____

_____

_____

Explain why the prediction based on the data might be wrong.

_____

_____

_____

_____

_____

_____

_____

This extended constructed-response question measures Earth Science and Scientific Investigation. Students' responses were scored using a four-level scoring guide. The first sample student response received the highest score, **Complete**. To receive a score of **Complete**, a student's response needed to predict the relative temperature of the sand and water at noon and explain the answer. The student's also needed to give a satisfactory explanation of why the prediction might be wrong.

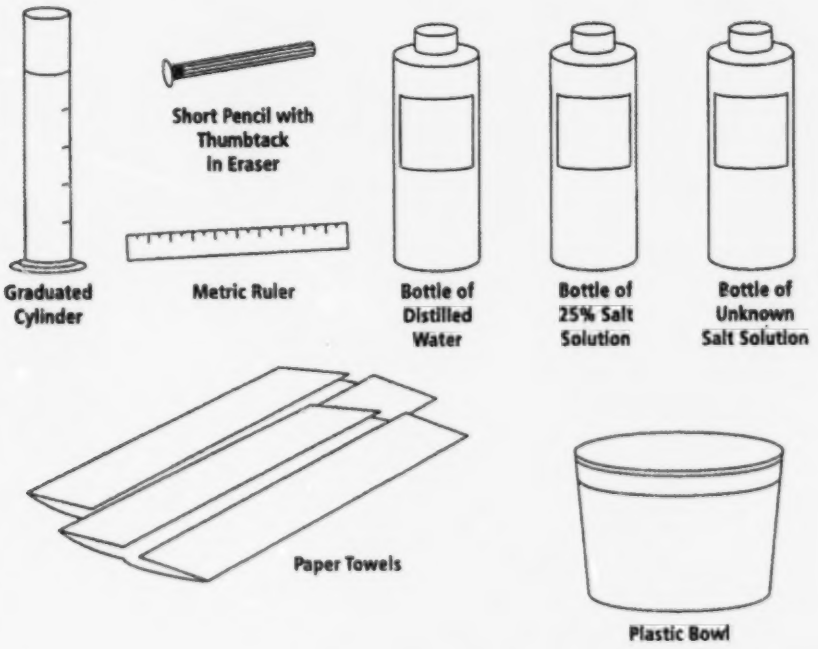
Percentages of Eighth Graders Receiving Complete, Essential, and Partial Scores

Complete	6%
Essential	6%
Partial	31%

SALT SOLUTIONS

Estimating the Salt Concentration of an Unknown Salt Solution Using the "Floating Pencil Test"

For this task, you have been given a kit that contains materials that you will use to perform an investigation during the next 30 minutes. Please open your kit now and use the following diagram to check that all of the materials in the diagram are included in your kit. If any materials are missing, raise your hand and the administrator will provide you with the materials that you need.



An instrument constructed from a pencil and thumbtack served as a hydrometer in this task. Students were asked to observe, measure, and compare the lengths of a portio of pencil, marked with calibrations for ease of measurement, that floated above the surface in distilled water and in a 25% salt solution. Based on these observations, the students were asked to predict how the addition of more salt to the salt solution would affect the floating pencil. Students then measured the length of the pencil that floated above the surface of a solution of unknown salt concentration and used the results of their previous observations to estimate the salt concentration of the unknown solution. The task assess students' ability to make simple observations, measure length using a ruler, apply observations to an unknown, draw a graph, interpolate from graphical data, and make a generalized inference from observations. The task also assessed students' understanding of the value of performing multiple trials of the same procedures.

Figure B.3 NAEP 1996 Science Sample Questions for Grade 8 (continued)

Now take the pencil out of the water and dry it with a paper towel. Use the ruler to measure the length of the pencil that was *above* the water. Record the length in Table 1 below under **Measurement 1**.

Table 1

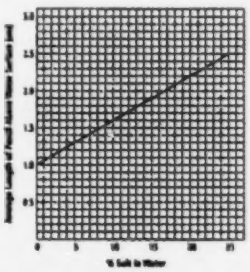
Type of Solution	Length of Pencil Above Water Surface (cm)		
	Measurement 1	Measurement 2	Average
Distilled Water			
Salt Solution			
Unknown Salt Solution			

Now place the pencil back in the distilled water and repeat steps 2 and 3. Record you measurement in Table 1 under **Measurement 2**.

Calculate the average Measurements 1 and 2 and record the result in the data table.

(You can calculate the average by adding Measurement 1 and Measurement 2 and then dividing by two.)

On the graph below, plot the average values you obtained for the distilled water and the 25% salt solution. Draw a straight line between the two data points. Assume that this line represents the relationship between the length of pencil that is above the water surface and the concentration of salt in the water.



Based on the graph that you plotted, what is the salt concentration of the unknown solution? _____

Explain how you determined your answer.

_____

_____

_____

_____

Measurement: Students' responses were scored using a four-level scoring guide. The sample student response received the highest score, **Complete** because the three sets of measurements agreed within tolerance and were in the correct relative order.

Percentages of Eighth Graders Receiving the Following Scores

Complete	Essential	Partial
42%	16%	21%

Average: Students' responses were scored using a three-level scoring guide. The sample student response received a score of **Complete** because the three averages were correctly calculated.

Percentages of Eighth Graders Receiving the Following Scores

Complete	Partial
57%	22%

Graph: Students' responses were scored using a three-level scoring guide. The sample student response received a score of **Complete** because the two data points were plotted correctly.

Percentages of Eighth Graders Receiving the Following Scores

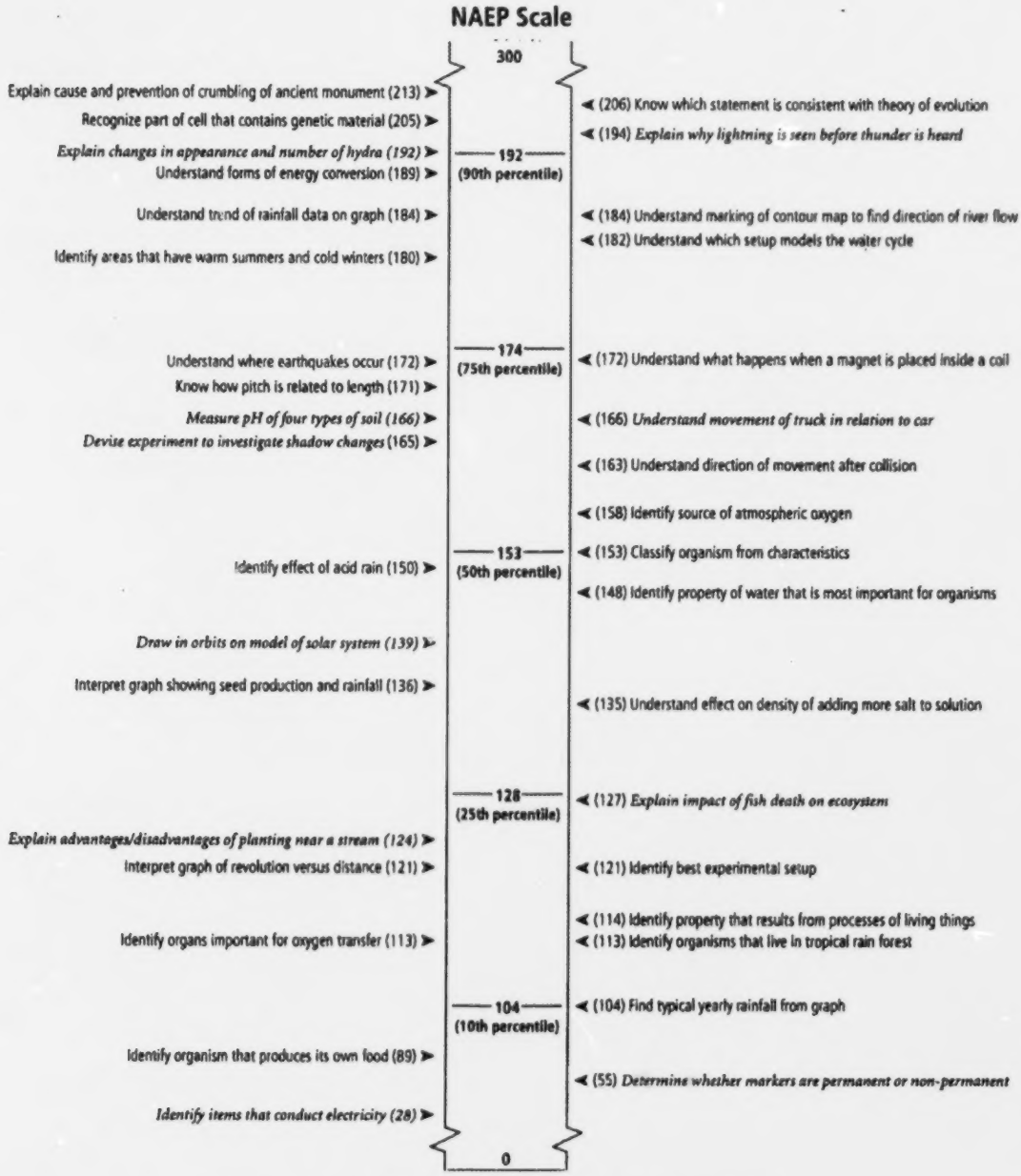
Complete	Partial
28%	19%

Interpolation: Students' responses were scored using a four-level scoring guide. The sample student response received a score of **Complete** because the concentration of salt in the unknown solution was interpolated correctly and a satisfactory explanation was given.

Percentages of Eighth Graders Receiving the Following Scores

Complete	Essential	Partial
20%	8%	16%

Figure B.4 Map of Selected Questions on the NAEP Science Scale for Grade 8


NAEP Scale
300
Explain cause and prevention of crumbling of ancient monument (213)
Recognize part of cell that contains genetic material (205)
Explain changes in appearance and number of hydra (192)
192
(90th percentile)
Understand forms of energy conversion (189)
Understand trend of rainfall data on graph (184)
Identify areas that have warm summers and cold winters (180)
174
(75th percentile)
Understand where earthquakes occur (172)
Know how pitch is related to length (171)
Measure pH of four types of soil (166)
Devise experiment to investigate shadow changes (165)
153
(50th percentile)
Identify effect of acid rain (150)
Draw in orbits on model of solar system (139)
Interpret graph showing seed production and rainfall (136)
128
(25th percentile)
Explain advantages/disadvantages of planting near a stream (124)
Interpret graph of revolution versus distance (121)
Identify organs important for oxygen transfer (113)
104
(10th percentile)
Identify organism that produces its own food (89)
Identify items that conduct electricity (28)
0
(206) Know which statement is consistent with theory of evolution
(194) Explain why lightning is seen before thunder is heard
(184) Understand marking of contour map to find direction of river flow
(182) Understand which setup models the water cycle
(172) Understand what happens when a magnet is placed inside a coil
(166) Understand movement of truck in relation to car
(163) Understand direction of movement after collision
(158) Identify source of atmospheric oxygen
(153) Classify organism from characteristics
(148) Identify property of water that is most important for organisms
(135) Understand effect on density of adding more salt to solution
(127) Explain impact of fish death on ecosystem
(121) Identify best experimental setup
(114) Identify property that results from processes of living things
(113) Identify organisms that live in tropical rain forest
(104) Find typical yearly rainfall from graph
(55) Determine whether markers are permanent or non-permanent

Note : Position of questions is approximate and on appropriate scale range is displayed for grade 8.
Italic type indicates a constructed-response question. Regular type denotes a multiple-choice question.

Each grade 8 science question was mapped onto the NAEP 0-to-300 science scale. The position of the question on the scale represents the scale score attained by students who had a 65% probability of reaching a given score level on a constructed-response question or a 74% probability of correctly answering a 4-option multiple-choice question. Only selected questions are presented. Percentiles of scale score distribution are referenced on the map.

Source: National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1996 Science Assessment.

Data Sources

National Assessment of Educational Progress (NAEP)

The National Assessment of Educational Progress (NAEP) is a congressionally mandated project of the National Center for Education Statistics (NCES) that has collected and reported information for nearly 25 years on what U.S. students know and what they can do. It is the nation's only ongoing, comparable, and representative assessment of student achievement. Its assessments are given to scientific samples of youths attending both public and private schools and enrolled in grades 4, 8, or 12. The assessment questions are written around a framework prepared for each content area—reading, writing, math, science, and others—that represents the consensus of groups of curriculum experts, educators, members of the general public, and user groups on what should be covered on such a test. Reporting includes means and distributions of scores, as well as more descriptive information about the meaning of different points on the NAEP scale.

NAEP's 1996 mathematics assessment included nearly 250,000 4th, 8th, and 12th grade students attending approximately 10,000 schools across the nation and the states, and the 1996 science assessment included 150,000 students in the same grades. The assessment itself was forward looking, comprising several hundred questions at each of the grades assessed. Consistent with the standards of the National Council of Teachers of Mathematics (NCTM) and the National Research Council (science), many of the questions required students to construct their responses; and some questions asked for explanations of their reasoning. For various portions of the assessment, mathematical and scientific tools and laboratory materials were supplied, including scientific calculators, protractor/rulers, and geometric shapes.

Nationally representative samples of students attending both public and private schools were assessed at grades 4, 8, and 12. Samples of 4th and 8th graders attending public schools were assessed in 44 states and three jurisdictions in math and 8th graders in science.

Schools and Staffing Survey (SASS)

In the 1987–88 school year, NCES launched a new survey with the goal of obtaining comprehensive, reliable data on the characteristics and condition of the nation's elementary and secondary schools and the teachers and administrators in the schools. The Schools and Staffing Survey (SASS) is conducted through questionnaires mailed to teachers, principals, and district administrators in a sample of the nation's public and private schools. It was conducted again in 1990–91 and 1993–94, and will be conducted again in 1999–2000.

The SASS is designed to provide data on the nation's elementary and secondary teaching force, aspects of teacher supply and demand, teacher workplace conditions, characteristics of school administrators, and school policies and practices. A major purpose of SASS is to provide comparable, reliable state-level statistics on the characteristics of schools and educators. The sample is designed to provide national estimates of schools, districts, teachers, and principals, and state-level estimates for public schools, districts, teachers, and principals. The sample for the survey comprised 9,500 public schools and principals, 5,400 school districts, and 56,000 public school teachers. The sample also included 3,000 private schools and 9,000 private school teachers. The survey sample was representative of public schools and teachers in each state. The average state sample included 185 elementary and secondary schools and 950 teachers.

Advanced Placement Examination (AP)

The Advanced Placement (AP) Program, a cooperative educational endeavor, is based on the premise that college-level material can be taught successfully to able and well-prepared secondary school students. Participating colleges, in turn, grant credit or appropriate placement to students who have done well on the AP Examinations. Almost 50 percent of the nation's 21,000 high schools offer some college-level AP coursework, and more than 400,000 students participate in the AP Program each year. Use by both schools and students has grown steadily in recent years.

In response to increased interest in the AP Program, the College Board produces, as part of its reporting process, a series of tables reflecting student participation in the 1996 AP Examinations. A more detailed understanding of AP trends and related information can be found in the companion publication, the *1996 AP Yearbook*.

The College Board annually publishes summary reports for the nation and for each of the 50 states. The reports give tables with the number of students taking examinations and the number receiving each grade: 1 = no recommendation, 2 = possibly qualified, 3 = qualified, 4 = well qualified, 5 = extremely well qualified.

State Data

State departments of education report aggregated totals on course enrollments and teacher characteristics in science and mathematics to CCSSO. Data are collected by states through state management information systems. Nine states report their data from student unit-record systems and teacher files, and the remaining states report data from school records and teacher files. The state totals for public schools are aggregated and reported to the Council using common data definitions and reporting forms (CCSSO, 1995). The data refer to the status of students and teachers on or about October 1. Each state's data codes for course enrollments and teacher assignments are cross-walked by CCSSO staff using the course taxonomy and common data category definitions developed by CCSSO with the states (see Appendix D).

For the science and mathematics indicators from the 1995–96 school year, 38 states, District of Columbia, and Puerto Rico reported some state-collected data. Data on science and mathematics teachers were reported by 40 states and course enrollments were reported by 35 states.

Computation of Estimated Proportion of High School Students Taking Selected Mathematics and Science Courses by Graduation

The percentages shown in Tables 7 and 10 for each course are statistical estimates of course taking of high school students by the time they graduate, based on the total course enrollment in grades 9–12 as of fall 1995 divided by the estimated number of students in a grade cohort during four years of high school.

Synthetic cohort statistics have been used previously in education. For example, a synthetic high school dropout statistic has been estimated, based on the sum of the percentages of students who drop out at each grade, for grades 9–12 (Kominski, 1993). Cross-sectional data on dropouts by grade are used to estimate a true dropout rate over a 4-year period of high school. A true dropout rate requires tracking the status of the same group of students (cohort) through four years of high school. If only cross-sectional data are available, the synthetic cohort statistic provides an estimate of the high school dropout rate.

The Science and Mathematics Indicators Project desired a synthetic cohort statistic of the proportion of graduates in a state that take a given course, e.g., Biology 1. Since most states do not collect data by grade, the approach used in computing a synthetic dropout statistic had to be revised. First, the numerator is the total number of students in grades 9–12 that took a given course, e.g., Biology, first year, in Fall 1995. The denominator is an estimate of the number of students in a cohort of students summed over a 4-year period of high school. For each state, the size of the cohort of students that have some probability of taking a given course, e.g., Biology 1, during four years of high school is estimated by: the state student membership in each grade (for grades 9–12) weighted by the regional percentage of students that took the course at each grade level, and summing the weighted memberships for each grade for grades 9–12. The state student memberships by grade are from the 1994–95 Common Core of Data (NCES) and the regional percentages were obtained from the 1994 National Transcript Study (Westat, 1994).

The computation of the science/mathematics course taking synthetic cohort statistic can be summarized as follows, using the example of Biology 1:

$$\text{Estimated proportion of students taking Biology 1 in state A} = \frac{\text{Biology 1 enrollment (9–12) (Reported by State A)}}{\text{Estimated number of students in cohort in grades 9–12 (from CCD and regional weights based on NAEP transcript study)}}$$

$$\text{Estimated students in cohort} = (M9 \times Bio\ 1/9) + (M10 \times Bio\ 1/10) + (M11 \times Bio\ 1/11) + (M12 \times Bio\ 1/12)$$

Where M9 is the student membership for grade 9 (from NCES Common Core of Data) Bio 1/9 is the percentage of 1994 graduates in state A's region that took Biology 1 in grade 9 (from Westat, Inc. transcript data files).

(Four regions designated by Westat—Northeast, North Central, South Central, and West.)

The estimated percentages of students taking a course by graduation, based on state data, can be compared with rates based on student transcripts from studies conducted by the National Center for Education Statistics. For example, national estimates of course-taking from 1993–94 aggregated state data (Blank & Gruebel, 1995) were: biology—95+%, chemistry—51%, physics—22%; while figures from the National Transcript Study (1994) were:

biology—94%, chemistry—56%, physics 24%. In mathematics, state aggregate data reported: geometry—65%, algebra 2—60%, trigonometry/precalculus—33%, calculus—10%; Transcript Study reported: geometry—70%, algebra 2—59%, trigonometry/precalculus—35%, calculus—9%. (We do not compare algebra 1 because transcript studies generally do not include 8th grade enrollments. State data showed 95+ percent of students taking algebra 1 by graduation; while the transcript study reported 66 percent.)

Thus, the comparison of rates by the two data collection methods show that transcript data produce slightly higher rates of course-taking. One reason for the difference is that CCSSO/state data were reported only during first semester, while the transcript data count all courses taken whether they are year long, first semester, or second semester courses. The transcript study rates have a small standard error (1% to 2%), while CCSSO estimates from state data include some error introduced by imputation for missing states. The CCSSO data from states could also be compared to student self-report data from NAEP assessments in mathematics and science. However, comparisons of self-reported vs. transcript data show that self-report data often have slightly inflated rates of course-taking.

Variability is added to the state estimates through the weighted student membership based on regional weights. Since the weights are not state specific, each estimate has variability. For this reason, estimates over 95 percent of students cannot be made with precision; and enrollments at this level are shown in Tables 7 and 10 as 95+ percent.

Course enrollment rates are based on enrollment as of fall 1995. Some states collect data on student course taking for fall and spring semesters. The state comparisons are based on cross-sectional data collected as of October 1. The indicator does not account for course taking in spring semester courses.

Imputation of estimated proportion of high school graduates taking selected mathematics and science courses for nonreporting states. In 1995–96, 35 states were able to report course enrollment data to CCSSO. To obtain a national total for the estimated proportion of graduates taking selected mathematics and science courses, the state proportions were imputed. The following formula was used for imputation:

$$\text{Estimated proportion of students taking Biology 1 in nonreporting state B} = \frac{\text{(Reg. avg. \% taking Biology 1 (9–12) x state B student membership (9–12))}}{\text{Sum of estimated numbers of students in cohort in grades 9–12 (from CCD and regional weights based on NAEP transcript study) (as above)}}$$

Where Reg. avg. % taking Biology 1 is the average (mean) percent of students taking Biology 1 among the reporting states in state B's region

Imputation of number of teachers per field (in mathematics, biology, chemistry, etc.) for nonreporting states.

$$\text{Imputed number of teacher of mathematics in state C} = \frac{\text{State student membership (9–12)}}{\text{Regional ratio students/teacher}} \times \text{Regional ratio of mathematics teachers to total teachers (9–12)}$$

$$\text{Regional ratio students/teacher} = \frac{\text{State student membership (9–12)}}{\text{State total teachers (9–12)}} \quad \text{Average for states in region}$$

$$\text{Regional ratio mathematics teachers to total teachers} = \frac{\text{State mathematics teachers (9–12)}}{\text{State total teachers (9–12)}} \quad \text{Average for states in region}$$

State Science and Mathematics Indicators (Fall 1995)

CCSSO INDICATORS

Science Course Categories

State Course Titles (from state data forms)

Grades 7–8

General Science, 7–8
General Science 7, 8

Life Science, 7–8
Life Science 7, 8

Earth Science, 7–8
Earth Science 7, 8

Physical Science, 7–8
Physical Science 7, 8

Integrated/Coordinated Science, 7–8
Science I, II; SS&C; Project 2061; Integrated Science 7, 8; Earth/Life/Physical Science 7, 8; Coordinated Science 7, 8

Other Science, 7–8
Other science courses for grades 7 or 8 listed under the "Science" category on state data collection form.

Grades 9–12

Biology, 1st Year
Biology I; General; College Prep.; Regents; Introductory; BSCS I

Biology, 1st Year, Applied
Basic Biology; Applied; Life Science; Biomedical Ed.; Animal Science; Horticulture Sci.; Bio. Science; Health Science; Nutrition; Man & Disease; Agricul. Science; Fundamentals of Biology

Biology, 2nd Year, Advanced Placement
Advanced Placement Biology

Biology, 2nd Year, Advanced
Biology II; Advanced; College; Psychobiology; Physiology; Anatomy; Microbiology; Genetics; Cell Biology; Embryology; Molecular Biology; Invertebrate/Vertebrate Biology; BSCS II

Biology, 2nd Year, Other
Zoology; Botany; Biomedical careers; Field Biology; Ecology; Marine Biology; Other Biological Sciences

Chemistry, 1st Year
Chemistry I; General; Introductory; Regents

Chemistry, 1st Year, Applied
Applied Chemistry; Consumer Chemistry; Technical Chemistry; Practical Chemistry; Chemistry in the Community

Chemistry, 2nd Year, Advanced Placement
Advanced Placement Chemistry

Chemistry, 2nd Year, Advanced
Chemistry II; Advanced; College; Organic; Inorganic; Physical; Biochemistry; Analytical

Physics, 1st Year
Physics I; General; Regents; Introductory

Physics, 1st Year, Applied
Applied Physics; Electronics; Radiation Physics; Practical Physics; Applied/Conceptual Physics; Electricity

Physics, 2nd Year, Advanced Placement
Advanced Placement Physics

Physics, 2nd Year, Advanced
Physics II; Advanced; College; Nuclear Physics; Atomic Physics

Earth Science, 1st Year
Earth Science; Earth-Space Science; Regents Earth Science; Space Science (courses that are generally taught at grade 9 and at introductory level)

Earth Science, 1st Year, Applied
Applied Earth Science; Fundamentals of Earth Science; Soil Science

Earth Science, 2nd Year, Advanced/Other
Advanced Earth Science; Earth Science II; Oceanography; Aquatic Science; Marine Science; Astronomy;

Geology; Meteorology (courses that are generally taught at grade 10, 11, or 12 and at higher level than Earth Science, 1st Year)

General Science

General Science; Basic; Introductory; Consumer Science

Physical Science

Physical Science; Interaction of Matter and Energy; Applied Physical Science

Integrated/Coordinated Science

Science III, IV; SS&C; Project 2061; Integrated Science 9, 10; Unified; Comprehensive Ideas of Investigations in Science; Life/Physical Science; Earth/Life/Physical Science; Coordinated Science

Environmental Science

Environmental Science; Environmental Education

Technology (taught as science course)

Principles of Technology I, II; Science/Technology/Society; Tech. Prep. Science; Biotechnology; Histologic Technology

Other Science

Science/Math; Engineering; Bioengineering; Special Interests Science; Energy; Research Topics; Laboratory Management; Aerospace Science; Aviation; Other science courses for grades 9–12 listed under the "Science" category on state data collection form.

Mathematics Course Categories

State Course Titles (from state data forms)

Grades 7–8

Remedial Math, Grade 7

Remedial Math 7

Math, Grade 7, Regular

Math 7; Exper. Math 7-SS MCIS

Math, Grade 7, Accelerated/Prealgebra

Accelerated Math 7; Prealgebra; Introductory Algebra; Honors Math 7; Enriched Math 7

Remedial Math, Grade 8

Remedial Math 8

Math, Grade 8, Regular

Math 8; Exper. Math 8-SS MCIS

Math, Grade 8, Enriched

Prealgebra; Accelerated Math 8; Honors Math 8; Enriched Math 8

Math Grade 8, Algebra 1/Integrated Math 1

Algebra 1; Beginning Algebra; Elementary Algebra; Integrated Math 1

Grades 9–12

Review Mathematics

Level 1

General Math 1; Basic Math; Math 9; Remedial Math; Developmental; H.S. Arithmetic; Math Comp Test; Comprehensive Math; Terminal Math

Level 2

General Math 2; Vocational Math; Consumer; Technical; Business; Shop; Math 10; Career Math; Practical Math; Essential Math; Cultural Math

Level 3

General Math 3; Math 11; Intermediate Math

Level 4

General Math 4; Math 12

Informal Mathematics

Level 1

Prealgebra; Introductory Algebra; Basic; Applications; Algebra 1A (first year of two-year sequence for Algebra 1); Math A; Applied Math

Level 2

Basic Geometry; Informal Geometry; Practical Geometry; Applied Math 2

Level 3

Applied Math 3, 4; Mathematics of Consumer Economics

Formal Mathematics

Level 1

Algebra 1; Elementary; Beginning; Unified Math I; Integrated Math 1; Algebra 1B (second year of two-year sequence for Algebra 1); Math B

Level 2

Geometry; Plane Geometry; Solid Geometry; Integrated Math 2; Unified Math II; Math C

Level 3

Algebra 2; Intermediate Algebra; Algebra and Trigonometry; Advanced Algebra; Algebra and Analytic Geometry; Integrated Math 3; Unified Math III

Level 4

Trigonometry; College Algebra; Algebra 3; Precalculus; Analytic/Advanced Geometry; Trigonometry and Analytic/Solid Geometry; Advanced Math Topics; Intro. to College Math; Number Theory; Math IV; College Prep Sr. Math; Elem. Functions; Finite Math; Math Analysis; Numerical Analysis; Discrete Math; Probability; Statistics

Level 5

Calculus and Analytic Geometry; Calculus; Abstract Algebra; Differential Equations; Multivariate Calculus; Linear Algebra; Theory of Equations; Vectors/Matrix Algebra

Level 5 Advanced Placement

Advanced Placement Calculus (AB, BC)

Other Mathematics, 9–12

Used only if state has a code for "Other Mathematics"

Computer Science Course Categories

State Course Titles (from state data forms)

Grades 7–8

Computer Science/Computer Programming

Introductory Programming (any language)

Grades 9–12

Computer Science/Programming I

Introductory Programming (any language); Programming I; Computer Language I

Advanced Computer Science/Programming II

Advanced Programming; Programming II; Computer Language II

Computer Science, Advanced Placement

Advanced Placement Computer Science

Source: Instructions and Reporting Forms for Data on Science and Mathematics Education in (each state). Council of Chief State School Officers, State Education Assessment Center, Washington, DC, Fall 1995.